airelectronics

UAV AUTOPILOTS

U-See Manual

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1. General System Introduction

Airelectronics has developed a complete solution for both rotary and fixed wing UAVs. The system is composed of:

- U-Pilot
- U-Ground
- U-See

U-Pilot takes care of the vehicle from Take-off to Landing. It is completely adaptable to any aircraft including fixed wing, multi-copters and helicopters.

U-Pilot is completely capable of following a flight plan with up to 200 points (real time editable). Once the flight plan is loaded on the U-Pilot it is independent of operator instructions. In case of a failure in the communications, U-Pilot starts a Landing maneuver which would safely land the UAV on the Runway Point.

Thanks to its versatility U-Pilot can control any device on board the UAV such as cameras, parachutes and others. These devices can be real time controlled by a Computer Operator or by U-Pilot automatically.

U-Pilot has, working in parallel:

- Up to 33 PWM (Pulse-Width Modulation) outputs or even more if necessary,
- 3 ADC inputs (Analogical Digital Converter) to monitor the voltages of three batteries on the UAV
- 4 serial ports RS232 to communicate with payloads, external magnetometers, etc.
- A radio with up to 100 km[1]
- GPS, dynamic and static pressure sensors, a magnetometer, gyroscopes and accelerometers.

U-Pilot is built using a two parallel microprocessor approach:

- One processor takes care of the state estimator and controls the UAV using hardware acceleration to calculate high speed algorithms.
- Another processor takes care of the mission at high level and the communications with the U-Ground and Payloads management.
- the processors do not waste any time doing low level tasks.

Due to the fact that those two processors are working in parallel and there is dedicated electronics taking care of all the serial ports, sensors, inputs and outputs the system is capable of recalculating its position, orientation and closing control loops at the speed of 1000 Hz. This high speed gives the UAV huge navigation accuracy and control.

On the ground segment, we have both U-Ground and U-See.

U-Ground is a control station with the other end of the radio link communicating the U-Pilot with the U-See software.

U-See software is a user friendly program that runs in any personal computer running Windows or Linux[2].

1 Range may vary with the frequency band used. Default is 900 MHz but legal limitations in some countries may change this.
2 MAC OS X can be available upon request, but it is considered a second-tier platform and some features may be unavailable.

Through U-See, the UAV operator can inspect the current state of the mission and command it in real-time.

All the U-Pilot configuration is done by Airelectronics staff so the End User does not have to waste any time setting the internal parameters of the system.

1.1 Concept of system operation

The system is made up of a U-Pilot installed in an aircraft connected to the U-Ground through a radio link. (See figure 1 attached below)

The U-Ground has its own radio link to communicate with the U-Pilot. It also has an RS-232 output to relay the data to a PC running U-See to allow control from the End User.

A Futaba Joystick allows manual override and control.

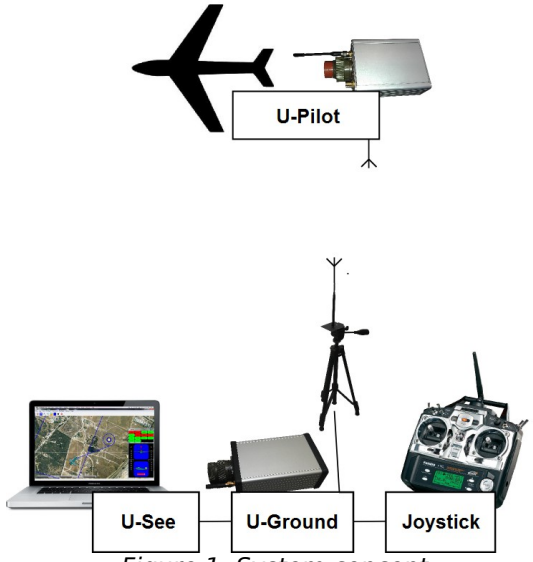


Figure 1: System concept

The mission team usually is formed by two persons:

- The External Pilot who will have the Futaba Joystick on its hands, in case a manual control of the UAV is desired (specially during the development and adjustment phase).
- The U-See operator that will command the mission using the PC.

2. U-See

2.1 Introduction

U-See is the software the operator will use to monitor and command the mission. All the information displayed by U-See comes from U-Pilot. This way the operator can be sure that the info displayed on the map is the actual information being used on-board for navigation and control.

The map engine connects to the Internet and fetches Geo-referenced maps and displays them for you. The End User is not required to manually load maps and worry about their alignment. However, it is possible to load such external maps through MapManager application that is distributed alongside U-See, and choosing map theme display is available in the settings dialog.

For operational deployments without Internet connectivity, U-See keeps a local cache of already displayed locations

2.2 Recommended Hardware

U-See runs on a standard PC.

The recommended hardware is the MacBook Pro 13” with BootCamp and Microsoft Windows 7.

Minimum hardware specification:

- Intel Core i5 processor.
- 2GB RAM.
- 4 GB free hard drive.
- OpenGL capable graphics Video Card.
- 13-inch (diagonal) screen.
- 1 RS-232 port or an available USB port with a serial USB to RS-232 converter.
- 1 Extra free USB port for license dongle.

All complex computer graphics drawn in U-See use OpenGL, the computer's video card is computing all the information. As a result, the processor load is lower and it is free to compute the mission information.

2.3 Software compatibility

U-See supports the main Operating Systems (Windows, Linux and MacOS X). However, MacOS X is considered a second-tier platform and some functionality may not be available when operating with MacOSX OS. Contact Airelectronics and we will provide you with the software that better fits your requirements.

2.3.1 Windows Installation

To install U-See on Windows follow the steps:

– Execute U-See-*1.0 Setup.exe*_(If asked about administrator permissions should be given, say yes) supplied (The version 1.0 may change depending on the software

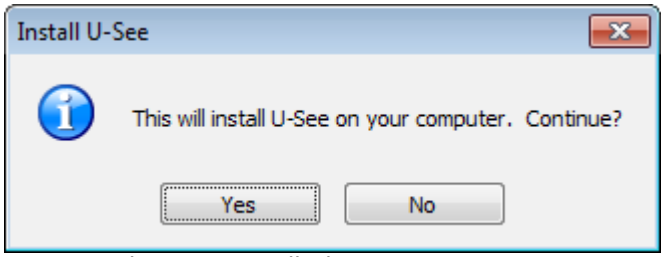


Figure 2: Installation process, step 1

version distributed). Click *Yes* button.

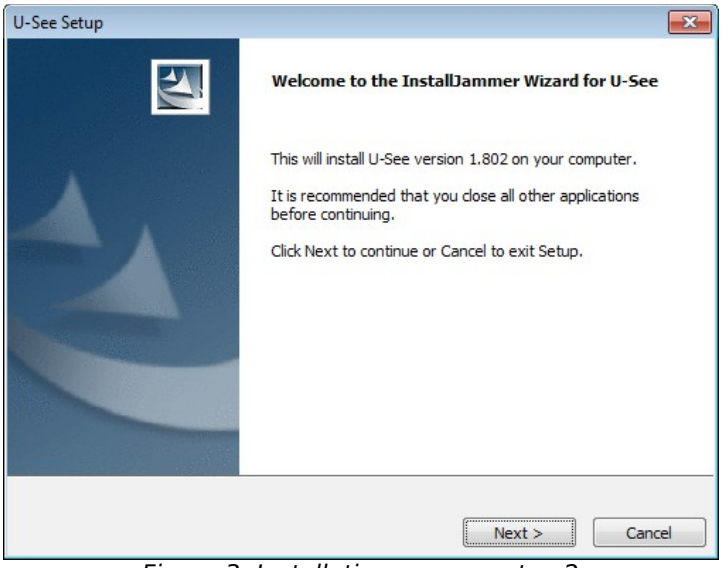

U-See Setup
Welcome to the InstallJammer Wizard for U-See
This will install U-See version 1.802 on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue or Cancel to exit Setup.
Next >
Cancel

Figure 3: Installation process, step 2

– Click *Next>* button

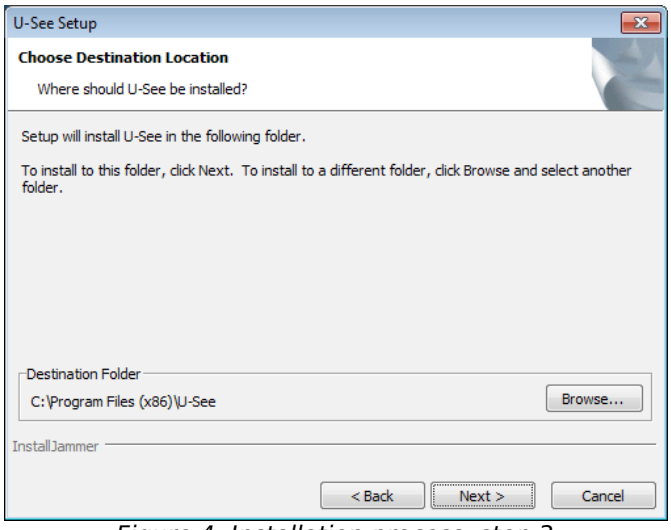

U-See Setup
Choose Destination Location
Where should U-See be installed?
Setup will install U-See in the following folder.
To install to this folder, click Next. To install to a different folder, click Browse and select another folder.
Destination Folder
C:\Program Files (x86)\U-See
Browse...
InstallJammer
< Back
Next >
Cancel

Figure 4: Installation process, step 3

– Choose the destination location and click *Next>*

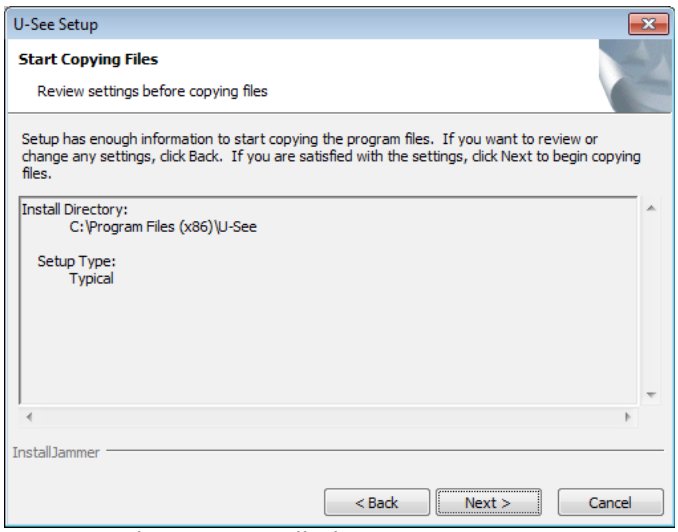

U-See Setup
Start Copying Files
Review settings before copying files
Setup has enough information to start copying the program files. If you want to review or change any settings, click Back. If you are satisfied with the settings, click Next to begin copying files.
Install Directory:
C:\Program Files (x86)\U-See
Setup Type:
Typical
InstallJammer
< Back
Next >
Cancel

Figure 5: Installation process, step 4

– Click *Next>*
– Wait for the copy of files finish

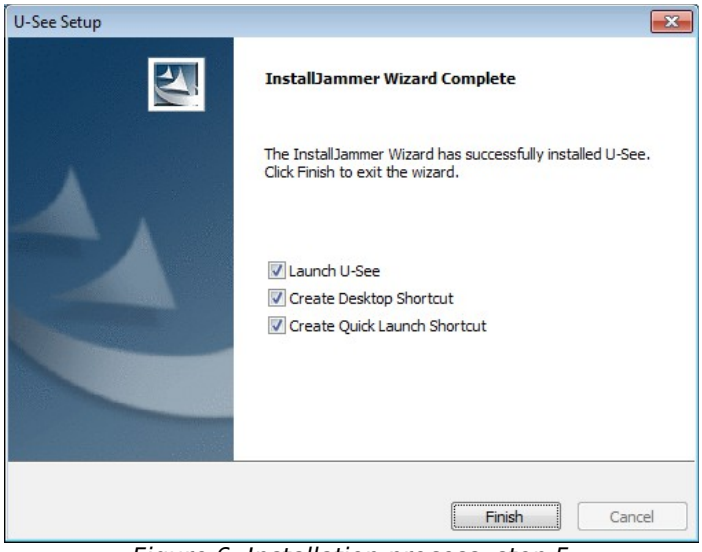


Figure 6: Installation process, step 5

– Click *Finish* to complete the installation.

2.4 Units and locale

Unit system used for data display is fully configurable through the U-See settings window (see section 2.12.10,U-See settings)

Available Units are:

- Distance:
  - kilometers
  - Nautical miles (1 nmi = 1852 m)
  - Statute mile (1 mi = 1609.344 m)
- Altitude
  - meters
  - Feet (1 foot = 0.3048 m)
- Speed
  - kilometers per hour
  - meters per second
  - knots (1 knot = 1 nmi per hour)
  - miles per hour
- Vertical speed indication
  - meter per second
  - feet per minute
- Temperatures
  - Celsius (°C)
  - Fahrenheit (°F)

Coordinates and angles are always shown using sexagesimal degrees. However coordinates presentation format can be changed between decimal coordinates format (e.g. 41.880263,-7.3828424) and sexagesimal coordinates format (41°52'48.9468”N 7°22'58.23264W).

When necessary to input a decimal quantity, the decimal separator used is “.” (the dot) and also in this document decimal quantities are presented in this way.

2.5 Map View

On start-up, the 0°,0° position is displayed with a drop-down menu bar and a toolbar.

Once the serial port is opened (See 2.6.1 Communications) and data starts arriving to U-See, the proper aircraft position will be displayed through an icon and the map will recenter.

Linked to the aircraft position icon, there is a small overlay summarizing UAV mode, speed and altitude status. However the display of this overlay is optional and it is controlled through the U-See Ground Settings dialog (see section 2.12.10,U-See settings)

To move the map click and drag on the screen using the left mouse button.

Zooming can be performed either by use of the mouse wheel, the keyboard shortcut “Ctrl+ -” and “Ctrl + +” or the “Zoom In” and “Zoom Out” actions in the tool-bar present in the main window.

Over-imposed on the map, the user will see a set of lines and points that describe the active and future operations of the UAV. The active task is always drawn in green, while all the symbology relating non-active features is drawn in blue (e.g. Figure 6, a flight plan is drawn in blue, i.e., it is inactive)

The UAV icon will leave behind a trail of color points. This color will reflect the climb speed. Red for positive climb rate and blue for negative climb rate.[3]

The operator can add additional windows on the drop-down menu as described on 2.8 View Menu: Real time information windows.

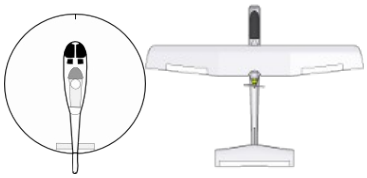
3 The presence of this trail is controlled by the maps settings in the U-See Settings dialog.

U-See 0.2
File Map View PreFlight Command PostFlight Settings Help
Record Data Communications ZoomIn ZoomOut State Command Camera
RET_NET
IAS: 50 ALT: 1030
GS: 54 AGL: 41
Mouse cursor: 40°54'27.579"N 4°22' 3.344"W
Terrain GPS Altitude: 992.001

Figure 7: Example screenshot of U-See. Note different colours for active and standby elements, trail with climb information and the small overlay

2.5.1 On Map icons

Home Position: This icon will be placed at U-Ground GPS position, provided U-Ground GPS antenna has sky visibility.



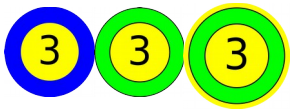
Aircraft Position: Depending the type of aircraft, one of these two icons will be placed on map at the reported U-Pilot position.

Future U-See releases will allow icon customization.

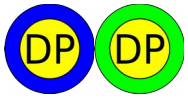
Landing Site Location: Reported Landing Site Location, proper orientation will be displayed on map.

Camera Target: Calculated center of camera pointing coordinates. It is only shown when the option “Show camera on map” option is checked in *Settings→ Ground Settings.*

Commanded Camera Target: This blue circle will be painted on the position the autopilot is trying to aim the camera, when in a Geo-referenced camera-mode, the previous icon should be firmly inside this one.



Flight-plan point: The number in the interior is the flight-plan sequence number. When the autopilot is in flight-plan mode, outer circle is colored in green, if not, blue is used instead. If the point is the current flight-plan destination, a yellow circle will enclose the icon.



Destination Point: This point is used to direct the aircraft when not in flight-plan, take-off or landing modes. In Fixed Wing aircrafts, active state will also include a representation of the orbit radio the aircraft will fly once the DP is reached.

Landing Hold center: Only displayed with fixed wing aircrafts, this icon marks the center of the hold pattern for landing *(See* Section 2.10.1.4.5 Landing mode)

2.5.1.1 Optionally available icons

Hereafter are listed those icons that only are displayed on some specific versions of the Software when some optional feature is enabled. They are listed here for the sake of completeness. These may not apply to your software version.

Base location: When operating in moving base mode using a relative GPS, the base location and heading is displayed with this icon

2.5.2 On Map Information Overlay

Linked to the aircraft position icon a small overlay will present basic status information:

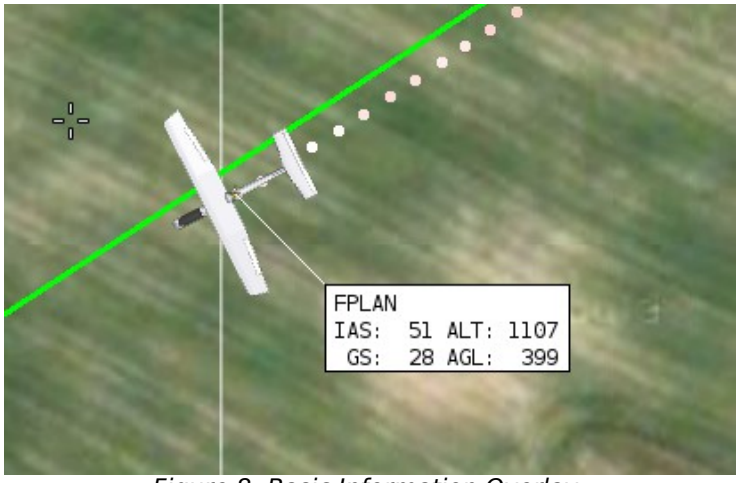


Figure 8: Basic Information Overlay

1. Mode indication: The list of mode abbreviation is found in Table 2: Fixed Wing Modes Key. and Table 3: Rotary Wing Modes Key
2. IAS: Indicated Air Speed
3. ALT: Altitude in meters over sea level.
4. GS: Ground Speed
5. AGL: Altitude above ground level. See note

AGL information is calculated using a Digital Elevation Model (DEM for short) incorporated into U-See.

Default DEM used in U-See has global coverage but, in exchange, its accuracy at some points may be lacking. Errors as high as 150 m. can exist.

Because of this, we advise to take AGL values with a pinch of salt, and only for broad informational purposes. Never fully trust these values for in-flight planning. A Safe terrain clearance should be kept at all times.

This warning still applies if high detail DEM is loaded instead of U-See default: DEMs usually do **NOT** include obstacles (as buildings and antennas) and terrain may have changed since the DEM preparation date because of human development.

2.5.2.1 Optionally available map overlays

When operating in moving base mode and the feature is enabled, next to the base position an overlay with information about course and speed of the moving base will be displayed. This information is only available in some U-See versions and this section may not apply to your version

2.5.3 GPWS Information display

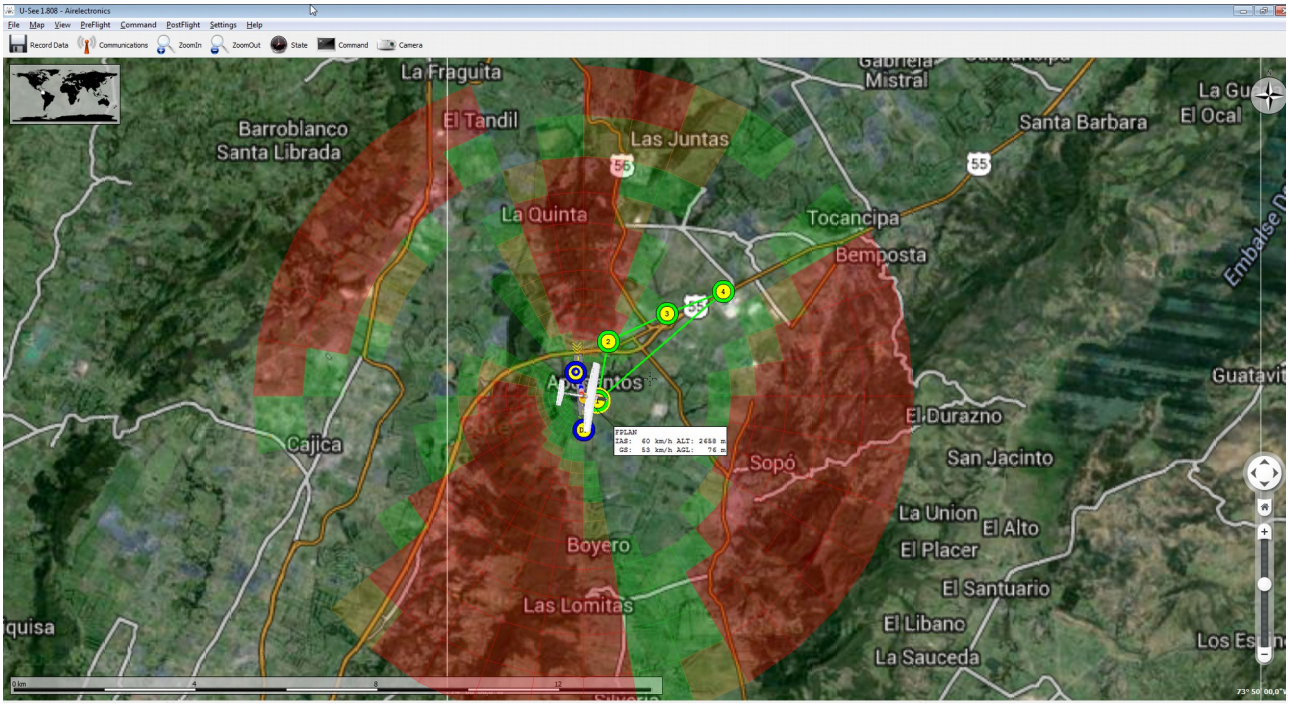


Ilustración 1: GPWS information display in action

GPWS is the acronym for Ground Proximity Warning System. When active (See 2.12.10.3 Maps & DEM configuration[4]) a circular gridded sector covering the aircraft's surrounding 8 km. will be displayed.

Aircraft is located at its centre. Innermost sector is a 300 m. circle which state is the worst of the surrounding adjacent grid elements.

At every corner of each grid element ground clearance is checked. Ground clearance is computed as current aircraft altitude minus the digital elevation model predicted terrain elevation at the element coordinates. The lowest ground clearance is checked against the configured GPWS warning levels (See 2.12.10.1 Alarms & Warnings):

- Ground clearance is negative of lower than the configured critical warning level. Grid element will be red coloured. This means that the terrain at that location is higher than current aircraft altitude, and a fly-to to this location without increase of altitude will surely cause a loss of the aircraft because if a controlled flight into the terrain.
- Ground Clearance is between the critical and warning level. Grid element will be yellow coloured. This means that while theoretically the ground should be lower that current altitude, antennas, man-made obstacles, digital elevation model errors, trees and other inaccuracies still pose a danger for the aircraft. A fly-to to these coordinates may cause problems for the aircraft.

4 DEM is an acronym for Digital Elevation Model

- If Ground clearance is between warning and low altitude level, the grid element will be painted in green. This shows that while there should be not problem at that altitude, terrain is near to be a problem.
- If ground clearance is above the low altitude level, the grid element will not be painted to avoid map clutter.

Whenever using a Digital Elevation Model it is important to remember that these are models, and models sometimes contain errors or inaccuracies. GPWS overlay is provided for additional situational awareness but is not substitute for proper flight planning.

2.5.4 Interacting with the Map View

Map interaction using the mouse has substantially changed starting at version 1.720

If you have used previous versions of U-See in the past, review this section carefully.

In case you are using an older version of U-See, contact Airelectronics for obtaining previous revisions of this document.

Map view is the main way of interacting with UAV navigation control. At all times, the map can be interacted with the left and right button of the mouse.

Right mouse button click opens a context menu, dragging the mouse with the left button pressed moves the map and simple left click is reserved for interactions that change navigation properties in the autopilot.

2.5.4.1 Right Button Menu

A right button click will bring up a menu containing the following entries:

- Coordinates of the clicked position: longitude and latitude are displayed.
- Elevation of the clicked point: Elevation of terrain is displayed[5]
- 'Point Camera Here' action: This will command the camera to point here when in Geo-referenced modes. This entry won't be shown if the “Show camera on map” option is unchecked in *Settings→ U-See Settings.*
- Distance From/To: Action to enable on map measuring (See following section)

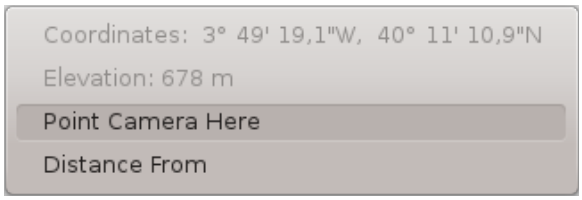


Figure 9: Right button click menu

2.5.4.2 Measuring on the map

At any given time, measurements can be made on the map. This is accomplished by:

5 For proper description of vertical datum, please, contact Airelectronics.

- Right clicking on the first measurement point and selecting “Distance From” from the context menu
- Right clicking on the second measurement point and selecting “Distance To” from the context menu.
- Distance between the two points will be presented in the left bottom corner of the map display, right above the scale display.

2.5.4.3 Left click interaction

Generally, Left button click sends through the radio up-link the order for the autopilot to change the position of the “Destination Point”. Trough this action, the intention to change the navigation target (while in the proper modes) is transmitted to the autopilot.

If autopilot has accepted this command the Destination Point should immediately move right to the clicked position on the map.

It may happen, due to ambient noise and byte losing in the radio-link while operating at long distance, that the destination point is not updated: shall this occur, just repeat the feft click action.

Exceptions to the “Left button click set destination point” rule exist:

- When editing a flight plan point (See Section 2.9.4 Flight-Plan) the left button click rules are a bit different:
  - Every flight-plan button has an “edit” mode in which the left click on the map picks coordinates for this point. While in this mode, the cursor will be transformed in a cross-hair and a tool-tip will be shown reading “Left Button Picks ID Point N”
  - When adding a new point to the flight-plan, left click will select the clicked coordinates as point coordinates. This change in behavior will be indicated by a cross-hair cursor and a tool-tip moving with the cursor that reads “Left Button click appends ID Point X. Altitude will default to maintain minimum flight-plan clearance”
- Whenever the “*Pattern Generation*” tool window is opened left click on map will add a point to the terrain outline (See Section 2.9.6 Pattern Generator)

2.6 File Menu

Under this menu are grouped all operations relating input and output of telemetry data.

2.6.1 Communications

The communications dialog controls the source of telemetry data presented all through the program. It is divided among communications with the primary UAV and communications with other systems, be it other ground stations or secondary telemetry from other UAVs.

2.6.1.1 "Comms with UAV"

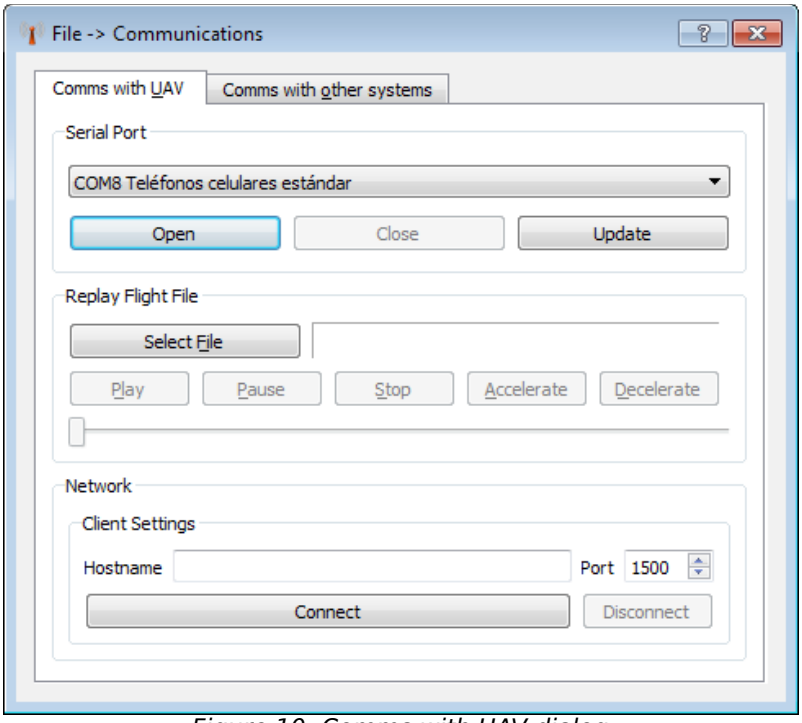


Figure 10: Comms with UAV dialog

At current version, primary telemetry data has three possible sources:

1. RS232 Telemetry data as supplied by U-Ground.
2. A previous flight recording file.
3. TCP/IP Telemetry received from another computer acting as a relay.

Only one source of primary telemetry can be active at a time, and only when connected through RS232 to the paired U-Ground unit commands can be uploaded to the autopilot on the aircraft, i.e. TCP/IP clients cannot command the UAV in the standard version[6].

To access the Communication Window click on the icon menu on the toolbar or go to *file → Communications.*

2.6.1.1.1 RS232 Telemetry (Serial Port section)

This is the main source of telemetry: A U-Ground unit connected to the computer through a RS232 link. Telemetry will be decoded from the stream and presented all through the program as soon as it is received.

Only while connected through the RS-232 serial port to U-Ground Software U-See will be able to upload commands to the UAV autopilot.

To start operation, select the proper port the proper port from the drop-down list and click on '*Open*'. Upon successful port opening, the dialog will disable the '*Open*' button and enable the *Close* button. Besides this, the rest of the dialog will be disabled and the main window will show a bar displaying current communications health.

Software will remember the last port used in previous sessions.

6 Remote control is enabled upon request.

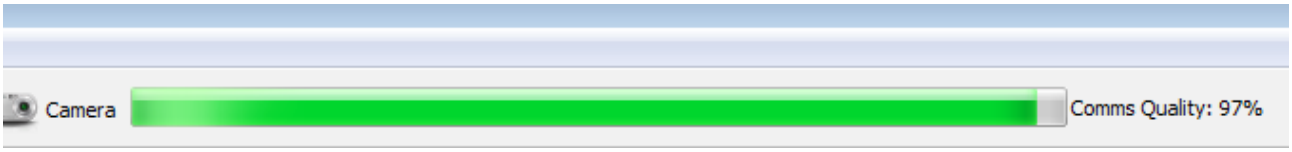


Figure 11: Communications quality display in main window

Only a source of telemetry at a time is possible, so, if RS-232 operation is desired and the *Open* button is disabled, click on *Stop* button in the *Replay Flight File* section or the *Disconnect* button in the *Network* section

2.6.1.1.2 Replaying a flight file

It is possible to replay an old recorded flight. To do so, click *Select File* and choose the file to replay in the dialog that will open.

Once opened it is possible to pause, accelerate and decelerate with the corresponding buttons, or select a specific time of the flight using the slider bar.

While the replay is ongoing the rest of the dialog will be disabled.

Only a source of telemetry at a time is possible, so, if replaying a previous flight is desired and the *Select File* button is disabled, click on *Close* button in the *Serial Port* section or the *Disconnect* button in the *Network* section

2.6.1.1.3 Network client

U-See can decode telemetry received through a TCP/IP connection and relayed by another computer connected through RS-232 to U-Ground. Only the U-See instance connected physically to the serial port of the U-Ground receiving hardware will have the capability to emit a command to the UAV[7].

To operate in this manner, write the hostname (or IP) and port the server is and click on *Connect.* Upon successful, connection, the rest of the dialog will be disabled, the *Connect* button will be grayed out and the *Disconnect* button will be enabled.

Hostname resolution is supported, as well as IPv4 and IPv6 ips.

Only a source of telemetry at a time is possible, so, if networking client operation is desired and the *Connect* button is disabled, click on *Close* button in the *Serial Port* section or the *Stop* button in the *Replay Flight File section.*

U-See can still operate as a server of data while in network client mode. This allows daisy chaining several copies of U-See, although this is not recommended.

2.6.1.2 Comms with other systems

This section of the dialog is used to re-transmit the received data to third systems, even allowing a translation of protocol to allow intercommunication with different manufacturer's system.

Current standard U-See version won't accept a command from a client connected to this export facility. To allow such behaviour, please, contact Airelectronics with your request.[8]

7 Modified versions that allow remote controlling are available on request.
8 Typical use-case for this feature is control handover over network.

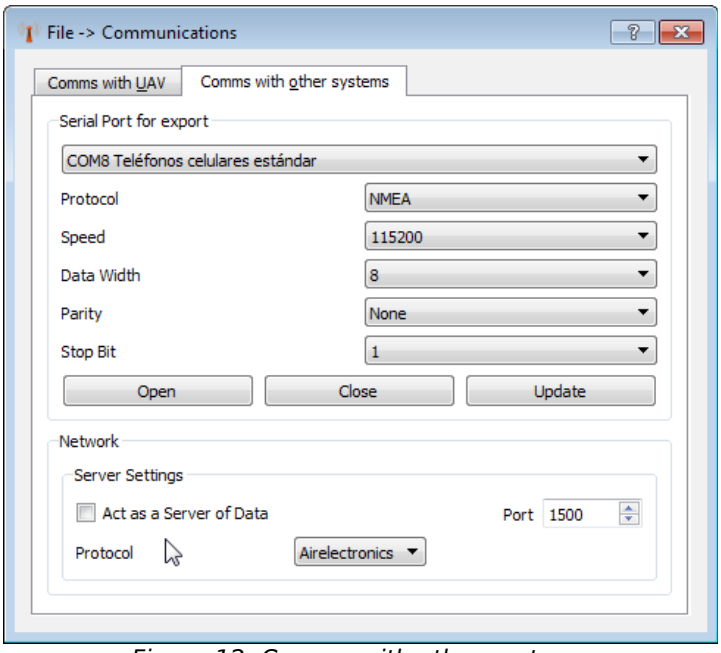


Figure 12: Comms with other systems

2.6.1.2.1 *Serial port for export*

Telemetry data is re-exported using a serial-port. Port Speed, data width, stop bit number and parity are configurable.

Said data exported is formatted according to the selected data protocol.

Current standard protocols for serial export are:

- NMEA 0183: Due to limitations in the NMEA protocol, only the current position and altitude is exported with NMEA protocol.

2.6.1.2.2 *Networks → server of data.*

No matter what is the actual source of the data, U-See can retransmit said data to other computers using a TCP/IP connection.

To enable this behavior, select the desired port to listen on[9] and check the *Act as a server of data checkbox.* To disable, un-check the option.

Up to 8 clients may connect to a data server, although this number can be increased by using daisy chaining.

Protocol of the exported data can be selected through the available menu. Current protocols available through network are:

- Airelectronics' telemetry data: To expose the data to another U-See instance
- NMEA 0183 position data: Due to limitations in the NMEA protocol, only the current position and altitude is exported with NMEA protocol.

2.6.1.2.3 Extra export protocols

Your U-See version may have extra available export protocols. Please check specific documentation for those options.

Extra protocols can be developed upon request. Please, contact Airelectronics for details.

9 Elevated privileges may be necessary for ports under 1024

2.6.2 Record Data

To access to the record window click on the icon menu on the tool-bar, or go to *File→ record data.*

To record the data from the flight click on S*elect File* and choose a file or create a new one by writing a new name.

Once a file is selected, click on start button to start recording the flight in the selected file and stop to finish recording. The recorded flights can be replayed afterward with by loading the generated file in the *Communications* dialog (See Section 2.6.1.1.2 Replaying a flight file).

An alarm, displayed in state window, is linked to the file writer status (See 2.8.5.1 Alarms section). When recording to a file, REC alarm is green and red when the file writer is not active.

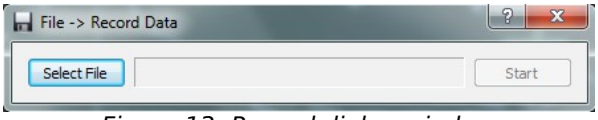


Figure 13: Record dialog window

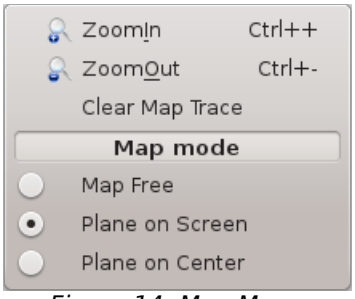


Figure 14: Map Menu

2.7 Map Menu

Behaviour of the map is controlled through this menu.

First two entries in the menu are the usual zoom in and zoom out commands.

Afterward, a *Clear Map Trace* entry is shown: This will clear the trailing points the map draw to represent past climb rate. By activating this entry, previous points will be forgotten and a new trail will begin to show.

Last section of the menu is a map mode selector:

- In Map Free you are free to move the map view and inspect whatever you wish.
- In Plane On Screen the map will re-center on the transmitted position if the actual position of the aircraft is not in the map view.
- In Plane On Center the aircraft will remain at all times at the center of the map view. This option may be heavy in CPU load and battery drain.

2.8 View Menu: Real time information windows

The U-See software have a set of windows that will report information to the user in real-time, allowing to control the current state of the UAV. These windows are shown independently to support multi-display environments more comfortably.

2.8.1 Sensors Summary

In sensors summary windows it's possible to see the real time data received by U-See concerning the on-board sensors. This window is divided in six windows:

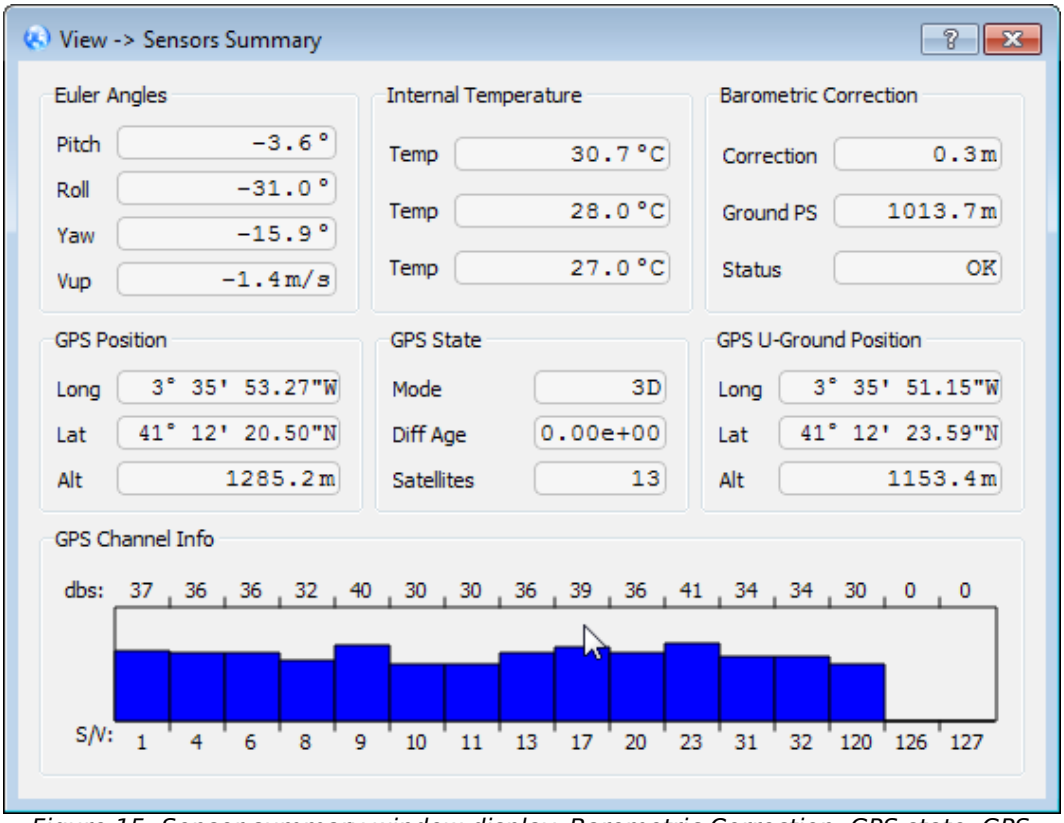


Figure 15: Sensor summary window display. Barometric Correction, GPS state, GPS Channels Signal

- Euler Angles and Vertical Speed: Representing the attitude of the vehicle and the vertical speed.
- Internal temperatures: Measurement from the internal temperature sensor/sensors in the autopilot. Triple sensor version will have three temperatures, while single sensor version will show only one.
- Barometric Correction: As an option, autopilot and ground control station exchange information to establish high precision barometric altimetry. This dialog allows monitorization of barometric correction status.

  Presented in this window, are the current barometric correction applied to on-board pressure sensor since last reference setting (See Section 2.12.6 Air Data System Settings), current ground sensed altimeter value in meters and a correction status description.

  Possible status are:

  - OK: Ground Sensor is working well and a valid reference was established so correction is being correctly applied.
  - BADSENS: Ground Sensor is failing for some reason and thus, high precission differential altimetry is not available. Should you find this condition, try power-cycling the U-Ground Hardware. If this condition persist, please, contact Airelectronics for support.
  - NOREF: No valid reference could be established. High precission differential altimetry is disabled.
  - NOCONFIG: Differential altimetry was not activated or is not supported by current autopilot and ground station pair.

- EXCESS: Excessive correction detected. If variation since reference was established surpass a threshold correction is discarded as invalid. This may be indicative of ground sensor failure. Please, contact Airelectronics for support in this case.
- NOTSET: Barometric altimetry has been never been crossed against GPS measurement in the current autopilot uptime. This is a typical situation encountered when the system has been powered-on recently and has never had a valid GPS fix. This implies that current static pressure indication may be off by several dozen of meters until an altimeter 'set' command is performed. For this, go to S*ettings → Air Data system* and press the ' Sync GPS & Altimeter' button. Valid GPS fix is necessary for this to work and the autopilot will perform automatically a set command when it has GPS fix calculated with at least 6 satellites.
- FILT: The Ground Control station indication of pressure have changed too fast in a very short time and the autopilot is introducing this correction in a filtered way to avoid sudden changes of altitude. This situation can occur when recovering contact with an UAV after a long period of communications blackout. Special attention is required in case this occurs.

- Position: shows data on GPS solution for current position in the UAV
- State: shows quality information regarding the fix:
  - Mode shows what kind of solution the GPS is offering. Possible modes are: 2D, 3D, DGPS and 'No Fix'.
  - Satellites show the number of satellites used to produce current navigation fix[10].
  - Diff Age: Shows how old is the data used for Differential correction
- U-Ground Position: GPS solution for the position of the Ground Control Station.
- GPS Channel Info*:* you will have access to the signal status of the tracking channels the GPS modules has. Informing you of which satellite the autopilot is tracking to compute its GPS position and what signal level is receiving from every satellite.

  The chart shows the identification of the Space Vehicle being tracked (SV ID). Those SV identified with numbers above 120 correspond to SBAS[11] systems such as WAAS or EGNOS.

  The chart displays also the signal level. Acceptable signal levels would be over 30 dbHz.

2.8.2 Relative GPS Status (Optional)

This window will be only displayed on moving base operations enabled versions of U-See. So this section may not apply to your U-See version

10 Do not mistake this number with the number of visible satellites over the horizon.

11 Satellite Based Augmentation Systems

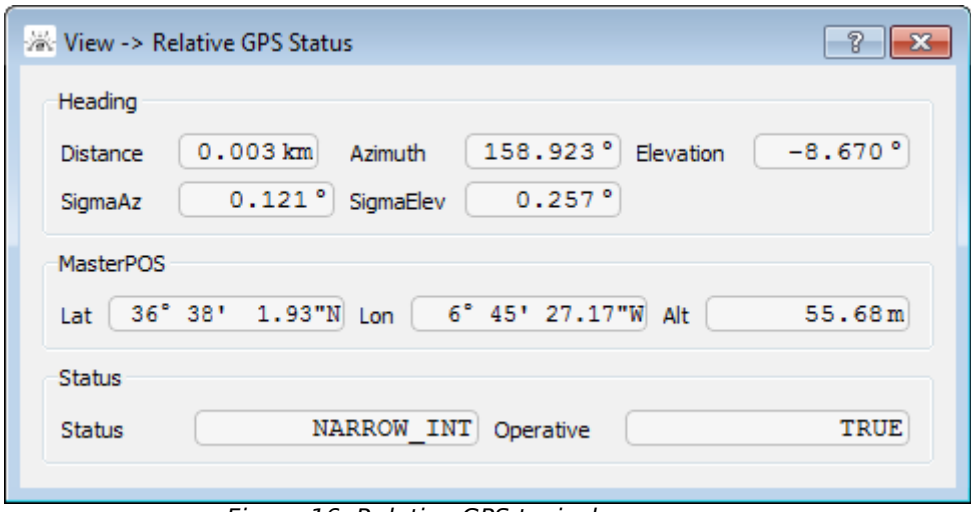


Figure 16: Relative GPS typical appearance

This window shows information about the current status of the Relative GPS solution. It will show the baseline distance and the azimuth and elevation of the baseline. Said azimuth and elevation is measured from geographic north and oriented in the Base-Rover direction.

Below this, there is indication about the quality of the solution by mean of indication of sigma(σ) value. This value shows the threshold in which a 60% of the measurements given by the system will be inside that threshold. Fully operational system should give sigmas in the range of the thousandth of degree.

MasterPOS shows the current GPS solution for the moving base position.

Status shows the kind of solution that is being computed and Operative shoes with a true or false indication if the system is usable for landing operation in a moving base.

Possible status for the solution are:

- None: System could not establish relative positioning.
- PSRDIFF: Solution comes from a differential correction of pseudo-ranges. Relative positioning obtained using this method is considered not valid for accuracy landings on moving bases, but could work for stationary approaches.
- L1_FLOAT: Floating L1 ambiguity solution. Typical sigma of this mode will be around 1°.
- L1_INT: Integer L1 ambiguity solution. Typical sigma of this mode is around 0.1°
- NARROW_INTEGER: Carrier phase wave-number is calculated using the maximum information possible. This is the desired state of functioning and typical sigma can be as low as 0.001°

Notice possible state are ordered from less to more accurate.

2.8.3 Video Capture (Optional)

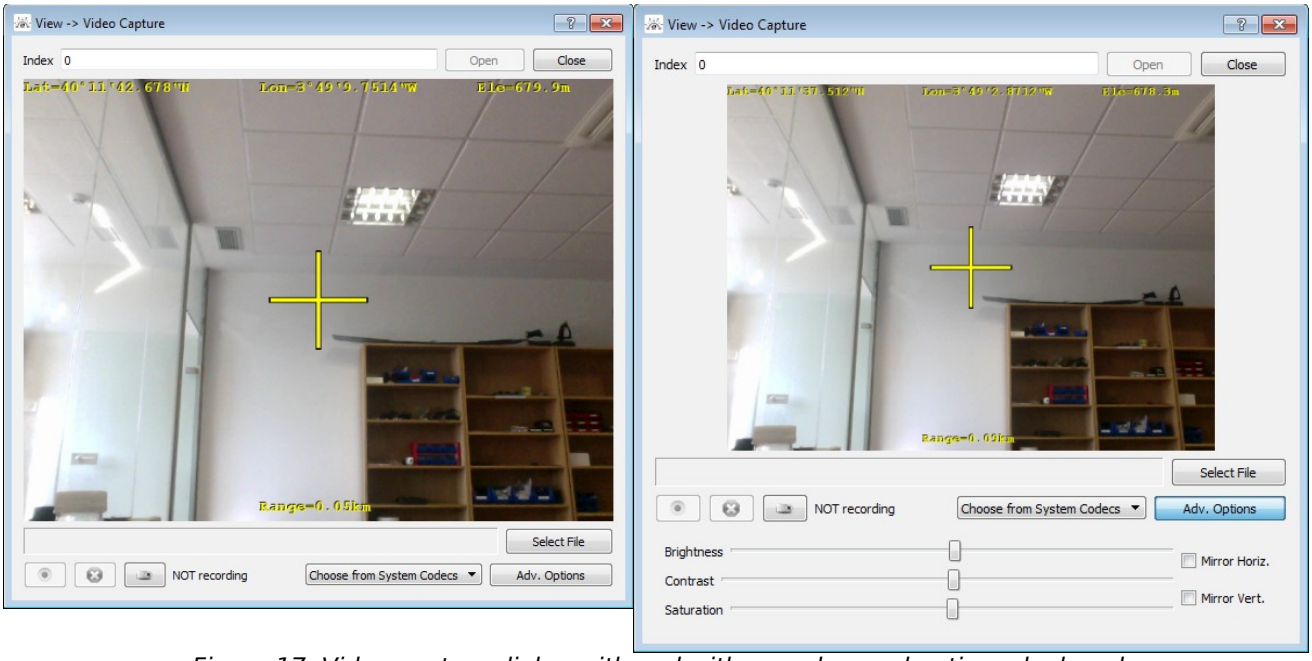


Figure 17: Video capture dialog with and withoug advanced options deployed

This is an optional feature and may not apply to your U-See version

U-See optionally supports opening video devices to show video as acquired by the UAV.

Video devices are opened indicating the system integer index. This is a current limitation we are working to remove, and in the future devices will be referred by name.

First video device connected to the system is index 0, second one is index 1, and so on. Through open and close button at the top the video feed is enabled or disabled.

The latitude, longitude and elevation shown at the top of the frame are the calculated positions of the centre of the image. Not the current position of the aircraft. At the bottom of the frame the distance to the landing site is over-imposed.

Video recording is also available through the buttons at the bottom of the dialog. To start recording, select a file-name to record to and the encoding facility to be used through the selector. Available options are:

- x264: Under windows a vfw filter is necessary to enable this codec
- h264: Under windows a vfw filter is necessary to enable this codec
- Raw Video: record raw frames to an avi container.
- Choose from system codecs: At the time of pressing Rec button a dialog will open presenting available system codecs to choose. This is only supported in windows. A known limitation is that sometimes this dialog appears without focus. Click on the windows taskbar entry to bring it to the front of the windows stack.

Once selected file-name and format, the recording button will be enabled and allow starting the recording.

While recording, it is possible to dump individual frames as pictures by using the third button in the bottom row.

Through the button “adv. Options” Brightness, Contrast and Saturation and mirroring options are exposed.

2.8.4 Synthetic View / Artificial Horizon

Go to *View → Synthetic View* to open the real time synthetic 3D vision.

The 3D view represents the aircraft surroundings with data provided by the Digital Elevation Model and the landing point location.

Additionally to the 3D environment information, the Synthetic View provides a lot of useful real time information through a HUD, such as speed, altitude, course or variometer.

Terrain elevation is generated using a Digital Elevation Model (DEM for short) incorporated into U-See.

Default DEM used in U-See has global coverage but, in exchange, its accuracy at some points may be lacking. Errors as high as 150 m. can exist.

'VISUAL' FLIGHT USING THIS VIEW IS STRICTLY FORBIDDEN. Its accuracy is not enough to keep the plane from running into ground. This view is supplied only as a way of improving situational awareness of the operator. Not as a tool to pilot the plane.

This warning still applies if high detail DEM is loaded instead of U-See default: DEMs usually do **NOT** include obstacles (as buildings and antennas) and terrain may have changed since the DEM preparation date by human development.

The HUD also represents the autopilot commanded values in yellow color and the commanded attitude in purple like a flight director. The variometer on the left side represents the instant variometer measure with a filled triangle and the filtered value with an empty one.

On the bottom of the display information about unit being used to present the data is given.

Information about the visualisation mode and flight mode is represented on the top left corner and the distance to the landing is placed on the right.

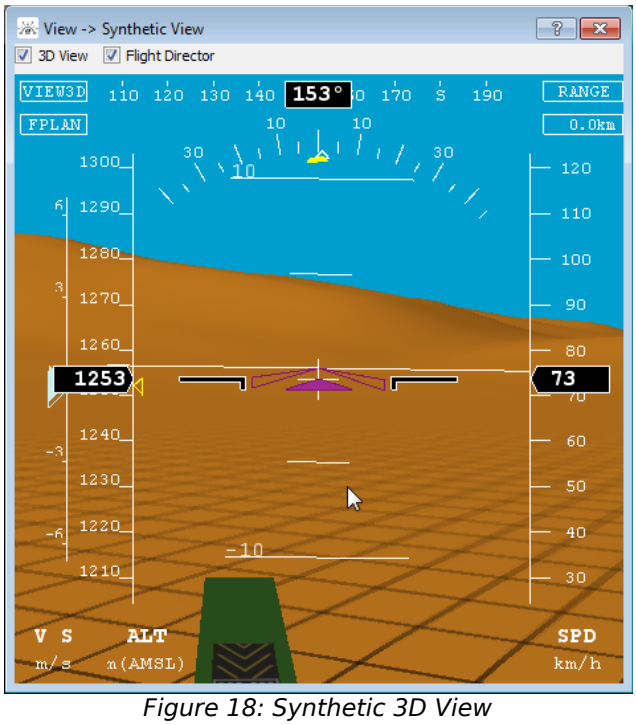


Figure 18: Synthetic 3D View

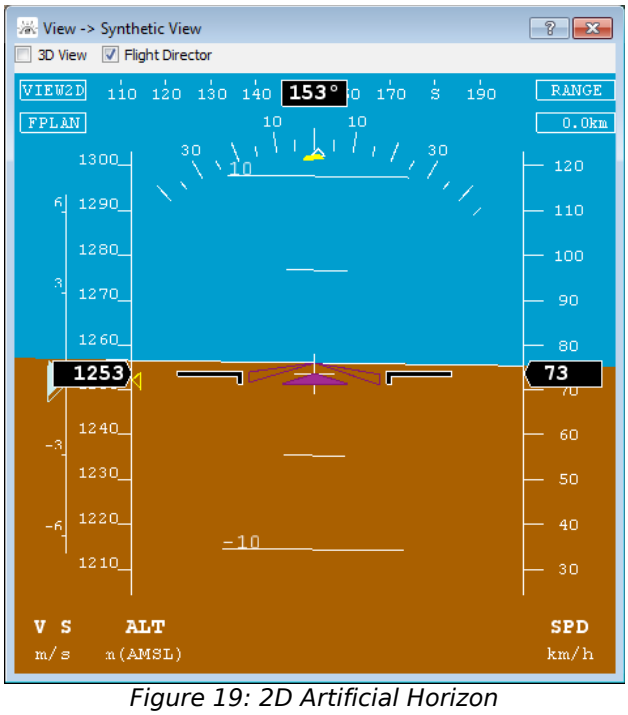


Figure 19: 2D Artificial Horizon

The 3D visualization can be deactivated in order to use a standard *Artificial Horizon* just unchecking *3D View* on the top of the window. Some HUD features, such as flight director can be switched on and off through its respective checkboxes.

Note that the 3D representation is only valid for visualization purposes and cannot be used for manual flights, as the precision of the 3D view is given by the Digital Elevation Model, and it is not 100% accurate.

2.8.5 State

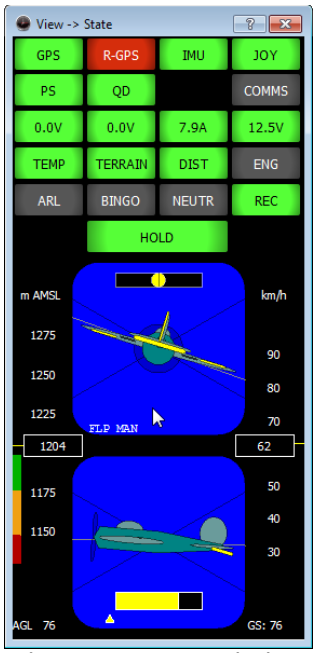


Figure 20: State window

To access to the State window click on the toolbar or go to *View→State.*

The State window is divided in two sections, alarms and surfaces information. The alarms section occupies the upper section, and the surfaces information is at the bottom region.

2.8.5.1 Alarms section

Figure 21: Alarms section of the State Window

On the alarms section is possible to see if all systems are working properly. To start a flight is necessary that all alarms are set in green. Notice that the magnetometer alarm (MAG) does not appear when using a fixed wing vehicle, and the dynamic pressure alarm (QD) does not appear when using a rotary wing vehicle.

A system operating properly will be reported by a green background. Any system in critical abnormal condition will be drawn with a red background. Systems that are operational but with some problem or limitation are presented with an orange background. Those system currently not being checked are displayed with a grey background.

Please note that the voltages alarms may be bounded by limits defined in U-See instead of the autopilot itself (See 2.12.10 U-See settings).

The table hereafter describes the meaning of the alarms.

Alarm	Green	Orange	Red
GPS	Valid navigation fix obtained from GPS	Not possible in this alarm	The system could not calculate a valid navigation fix.
R-GPS	Relative GPS system operational	Not possible in this alarm	Relative GPS system is not in valid operational state.
IMU	Gyro and Accelerometer are working properly	This state indicates that measurements from different sensors are inconsistent and the sensor suite is operating in a degraded mode.	A failure in the sensor suite has made the attitude estimation unreliable.
JOY	Connected Joystick and receiving data.	Not possible for this alarm	Joystick not found
PS	Correct static pressure values	Barometric altimetry has some problem which reduces its accuracy. Check section 2.8.1 Sensors Summary for detailed information	Static pressure measure failed or out of range
QD	Correct dynamic pressure values (Not used in rotary wing vehicles)	Not possible for this alarm	Static pressure measure failed or out of range (Not used on rotary wing vehicles)
MAG	Receiving magnetometer signal (Not used on fixed wing vehicles)	Not possible for this alarm	Not logical magnetometer values or out of range (Not used on fixed wing vehicles)
COMMS	Communications level is above 60%	Communications level is below 60% but above 40%	Communications level is below 40%
Internal battery 1	ADC1 voltage value within configured limits	Not possible for this alarm	ADC1 voltage value out of configured limits.
Internal battery 2	ADC2 voltage value within configured limits	Not possible for this alarm	ADC2 voltage value out of configured limits.
Internal battery 3	ADC3 voltage value within configured limits	Not possible for this alarm	ADC3 voltage value out of configured limits.
Internal battery 4	ADC4 voltage value within configured limits	Not possible for this alarm	ADC4 voltage value out of configured limits.
TEMP	Autopilot temperature is between 10°C and 60°C	Autopilot is between 0°C and 10°C or between 60°C and 70°C	Autopilot temperature is below 0°C or above 70°C
TERRAIN[12]	According to current DEM and current UAV 3D velocity, the next 20 seconds do not present risk of entering proximity of the ground	According to current DEM and current UAV 3D velocity, the UAV will, at some point in the following 20 seconds, be in moderate proximity with the terrain.	According to current DEM and current UAV 3D velocity, the UAV will, in the following 20 seconds, be in close proximity with the terrain.

12 To define how close is too close, altitude warning levels can be configured through *settings → U-See Settings*. Check section 2.12.10 U-See settings

Alarm	Green	Orange	Red
DIST	UAV is within specified distances limits	Not possible for this alarm	UAV is farther than configured distance limit
ENG	Engine is operating within limits	The Engine is operational but some operation parameter is in degraded mode. Check engine data window under *view → engine data* for further info	Engine is not operational or some fault is being reported that severely compromises the continuity of flight. Also red when, in electric vehicle, battery level falls beyond configured limit.[13] Check engine data window under *view → engine data* for further info
ARL (Auto Return Limits) (Note that Bingo time and COMMs have their own alarm and it is not included in this one.)	Some limit for auto-return in mission supervisor was surpassed and a return home is recommended. [14]	Not possible for this alarm	Never in the uptime of the auto-pilot an auto-return home request has been issued by mission-supervisor limits.
Bingo time (2.9.5 Bingo Time)	Remaining Bingo time displayed	Not possible for this alarm	Bingo time exceed “BINGO” is displayed
Camera Mode. Text will display current mode.	Not possible for this alarm	Not possible for this alarm	Not possible for this alarm
REC	Recording data	Not possible for this alarm	Not recording data
Mode[15]	Flight mode selected	Reduced control mode active.	Autopilot mode active has very limited or none control ability and could cause a crash if unattended (e.g. Manual mode)

Table 1: Alarm descriptions

13 Check section 2.12.10 U-See settings for details on how to set battery limit for alarm.
14 This feature may be not present in your version of U-See.
15 Check Table 3: Rotary Wing Modes Key and Table 2: Fixed Wing Modes Key. for the meaning of mode key displayed as text in this alarm

Fixed wing modes	
Reported mode in alarms	**Meaning**
MANUAL	Manual mode
FLYTO	Fly to mode
ROULETTE	Roulette mode
RETURN	Landing mode: Returning towards the landing field
HOLD	Landing: Hold a circular pattern to adjust UAV altitude to a proper value for final
FINAL	Landing: Executing Final approach
FLARE	Landing: executing landing flare to touch ground
SERVOS	Servo adjustment mode.
LOOPS	Internal Loops mode
ORBITING	Orbit mode, the UAV will describe circles around a set point
FPLAN	Flight plan. UAV will follow flight plan point by point
TAKE-OFF	Take off: UAV is executing a take-off maneuver.
CATARM	Catapult launch is armed. Autopilot is waiting to detect movement to go into full Take-Off mode.
ABORT	Autopilot is executing a pre-programmed abort manouver.
S-FLYTO / S-ORBIT	Equivalent to FLYTO and ORBITING but with moving base support. These modes will maintain relative geometry to the moving base.
RET_NET	Landing Mode: Returning for a net Landing with a moving base
HOLD_NET	Landing Mode: Hold pattern for net approach with a moving base
FIN_NET	Landing Mode: On final approach for net landing with a moving base.
L-TAKE0FF	Auto-Learn TakeOff: For hand launched aircrafts.

Fixed wing modes	
Reported mode in alarms	**Meaning**
SAFE-RET	Come Above mode: In this mode the UAV will navigate to the vertical of the landing site and start an orbiting upon arrival.

Table 2: Fixed Wing Modes Key.

Modes with yellow background and aircraft-specific modes and may be unavailable for your U-See version.

Rotary Wing modes	
Reported mode in alarms	**Meaning**
MANUAL	Manual mode
NAV	UAV will navigate to a set point and keep a hovering flight over this point at the commanded altitude when arrived.
FPLAN	Flight plan mode.
TAKE-OFF	Take off Mode
LANDING	Landing Maneuver on progress
SERVOS	The system is in servo adjustment mode
ELOOPS	Interal Loops

Table 3: Rotary Wing Modes Key

NOTE: Servo adjustment mode and internal loops are not flight modes, and they should never be commanded during an actual flight.

Camera mode	Meaning
FORW	Forward looking: Camera will look straight ahead of UAV
MANUAL	Camera will point whatever value the user has selected
STABILISED	Camera will compensate for attitude variations of the camera.
GEO	Camera will compensate attitude changes AND Position changes, looking to a fixed point on ground
NEUTRAL	Camera actuators are positioned in neutral state
LATERAL	Special Lateral Mode

Table 4: Camera Modes Available

2.8.5.2 Surfaces section

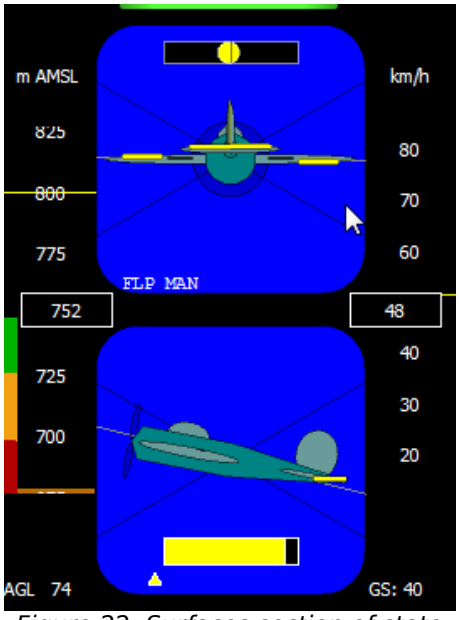


Figure 22: Surfaces section of state window

On the surfaces section there is information about the position and command of the UAV.

On the left side the current altitude is displayed into the white square and the commanded altitude is represented by a yellow line. In case the commanded altitude is out of the range displayed at that moment, a yellow arrow appears on the commanded altitude direction.

Terrain level according to current loaded DEM is represented by a solid brown background, and colored segments on the left side of the altitude scale represent current selected DEM warning levels.

When supported (optional feature of the autopilot), a sliding triangle will show on the left margin indicating altitude the aircraft should be at to comply with the current vertical performance limit (See 2.10.1.3 Vertical Performance limits)

On the right side of the section, the current speed is displayed into the white box in the same way as the altitude, and the commanded speed is represented by a yellow line.

On top of both columns an indication showing current display unit is present.

In a rotary wing UAV the commanded speed controls the speed that the vehicle uses to transition between commanded points. If it is already over the designated point, it will start a hover, thus its speed will be 0, regardless of the commanded speed, as there is no need to execute a transition.

On the center of the section there are two screens showing rear and lateral view of the plane with real time information about its attitude is displayed.

On the upper screen (rear view) the roll position of plane is displayed, and the commanded roll is represented by a yellow line. On the same screen the commanded surfaces are represented in yellow. On top of this screen there is a representation of the turn coordination (ball display).

Whenever the flaps (FLP MAN) or airbrakes (ABK MAN) are configured to be deployed in manual mode, a reminder will show at the bottom of the rear view.

When active, in the black segment between both views a reminder of current vertical performance limit will be displayed at the left margin.

If the speed control is adjusted for Economic flight (See 2.10.1.2 Normal and ECO flight laws), the word ECO will be displayed by the speed rectangle.

On the lower screen (lateral view) the pitch position of plane is displayed, and the commanded pitch is represented by a yellow line. On the same screen the commanded surfaces are represented in yellow and the throttle is represented as a yellow bar.

Bellow the throttle bar, a triangle will be displayed. This triangle shows current throttle stick position in the manual pilot joystick.

Whenever the engine is disabled, a red cross will be displayed over the throttle command.

In the lower right corner ground Speed is given in km/h and in the lower left corner Above Ground Level (AGL) is given in meters.

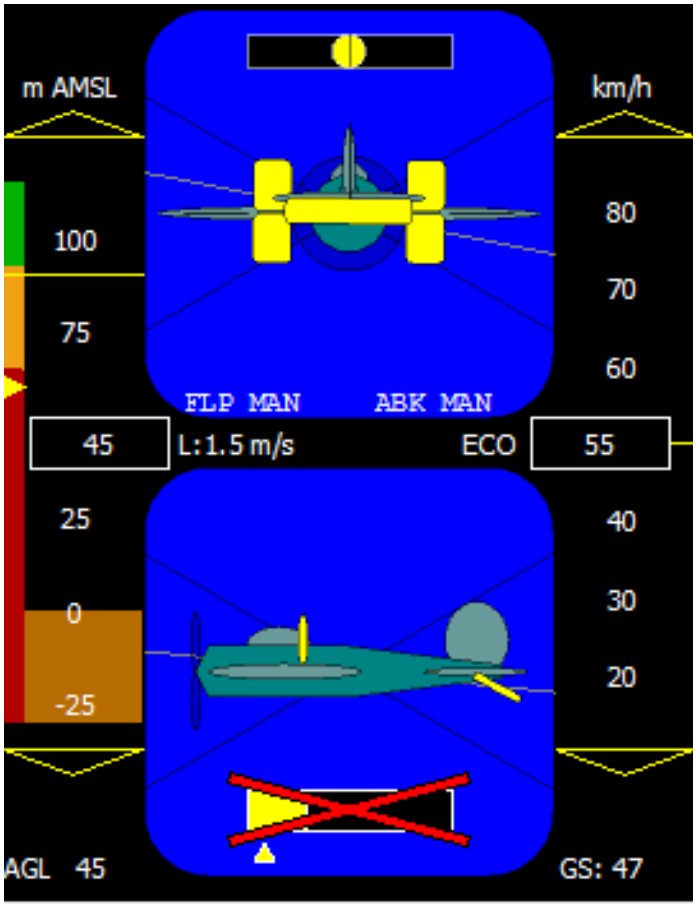


Figure 23: Full symbology display. Note that this is an artificially generated image. Some indications are mutually exclusive and won't be displayed at the same time (e.g. yellow triangles in speed and altitude display columns)

2.8.5.3 Alternate Surfaces section

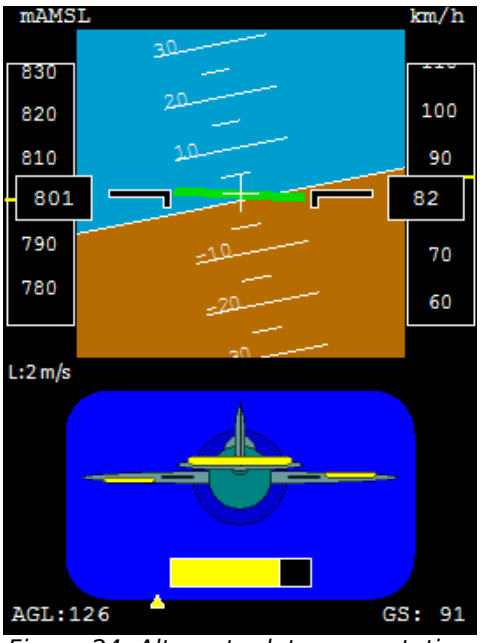


Figure 24: Alternate data presentation

Through *Settings → Ground Settings* a different data presentation option can be selected. The choice will we remembered between application sessions. **Unless previous experience with flight indicators, we don't recommend its usage.**

In the alternate representation, the main display is an artificial horizon (See figure 24) with a display of surface deflection immediately below.

On the left of the artificial horizon the altitude is displayed exactly in a box and with a sliding band below. Commanded altitude is represented through a horizontal yellow line

Terrain level according to current loaded DEM is represented by solid brown background, and colored segments on the right side of the altitude scale represent current selected DEM warning levels

On the right of the artificial horizon the speed is displayed in a box with a sliding band below. Commanded speed is displayed through a yellow horizontal line.

On top of both sliding columns an indication of current display unit is shown.

On the artificial horizon there is a display of wing bars and a crosshair to allow precise indication of pitch. A green flight director displays current autopilot command.

Below the artificial horizon, a rear view of the vehicle is shown, displaying surfaces deflection and current engine command represented by a yellow bar that increases from left to right. A red cross will be drawn on top of the throttle bar in case the engine is disabled. It indicates the autopilot is actively disabling the throttle command (where available; cutting engine injection). It does not indicate an engine failure or abnormality (That is shown through the ENG alarm in the alarms panel when supported).

Below the throttle bar, a triangle will show current joystick throttle stick position.

On the sides of the throttle bar, a reminder will be shown in case either flaps (FLP MAN) or airbrakes (ABK MAN) are configured to be operated in manual mode.

In the lower right corner ground Speed is given in km/h and in the lower left corner Above Ground Level (AGL) is given in meters.

Current vertical performance limit is shown if active and available (Optional autopilot feature) below the altitude scale.

Whenever Economic Flight mode is active, the word ECO will be shown below the speed scale.

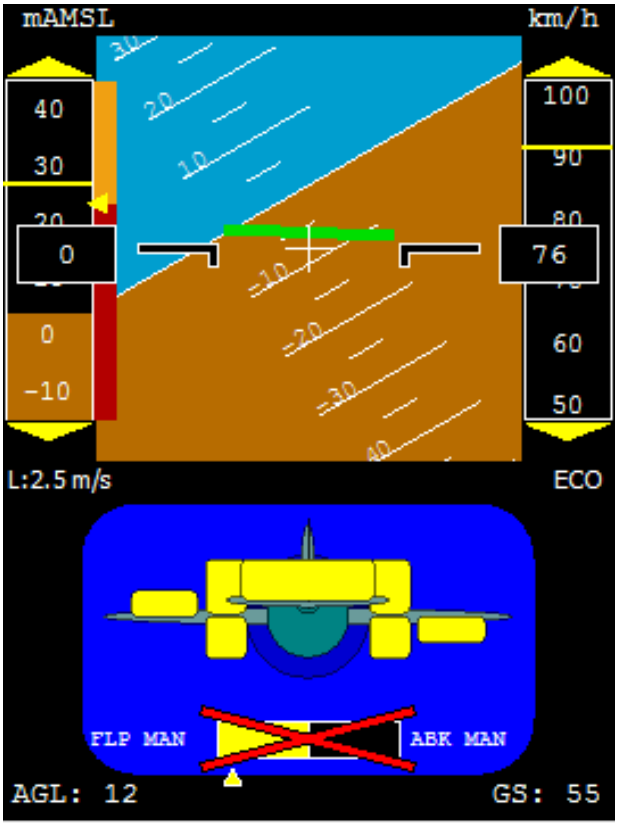


Figure 25: Alternate presentation: Full symbology. Note that this is an artificially generated image. Some indications are mutually exclusive and won't be displayed at the same time (e.g. yellow triangles in speed and altitude display columns)

2.8.5.4 Warning about AGL indication

AGL information is calculated using the selected Digital Elevation Model (DEM for short).

Default DEM used in U-See has global coverage but, in exchange, its accuracy at some points may be lacking. Errors as high as 150 m. can exist.

Because of this, we advise to take AGL values with a pinch of salt, and only for broad informational purposes. Never fully trust this values for in-flight planning. A Safe terrain clearance should be kept at all times.

This warning still applies if high detail DEM is loaded instead of U-See default: DEMs usually do **NOT** include obstacles (as buildings and antennas) and terrain may have changed since the DEM preparation date because of human development.

2.8.6 Joystick

To access to the Joystick window go to *View → JoyStick.*

This window provides real time information about the Joystick position in graphical form.

The purpose of this screen is to verify the correct behavior of the Joystick. Check that movement on the screen is the same than real movement of the sticks on the Futaba Joystick. In case it is not, change the Futaba settings.

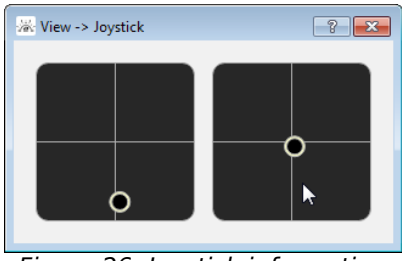


Figure 26: Joystick information window

The left half represents throttle in the vertical axis and rudder input in the horizontal axis.

The right half represents elevator input in the vertical axis and aileron input in the horizontal axis.

This axis assignment Is independent of mode (Mode /Mode II) configuration for the actual joystick.

2.8.7 Engine Data

Accessed through *View → Engine Data.* This tool is only available for electric vehicles and monitorized engines (ECU controlled engines)

2.8.7.1 Electric engine Data

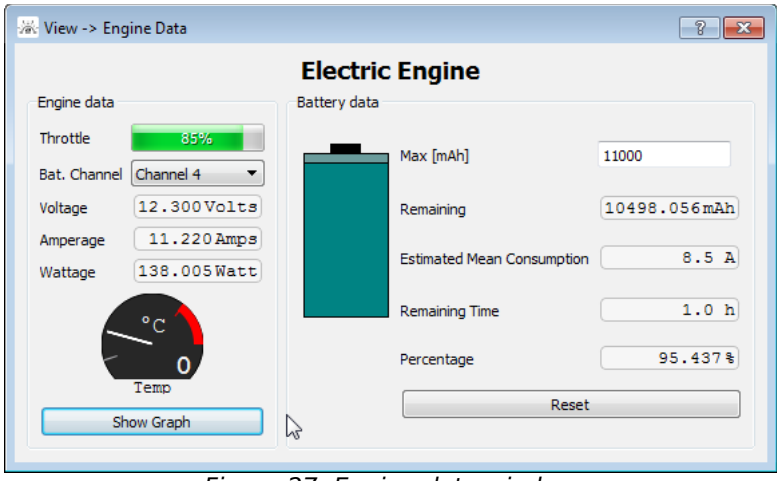


Figure 27: Engine data window

This menu is divided in two sections:

The *Engine data* displays, in real-time, the Throttle commanded to the engine, the main battery voltage, the amperage consumed by the system and the wattage.

As different autopilots have different main battery channel assigments, a drop-down select box is provided to select the proper main battery channel. This selector affects only the wattage calculation and the graphical plotter of wattage against IAS.

A real-time plot of the IAS (Indicated Air Speed) of the plane vs the Wattage of the engine can be shown with the *Graphs* button on this section. The IAS is shown on the horizontal axis with unit indication in the right bottom corner while the instantaneous power is shown on the vertical axis in Watts.

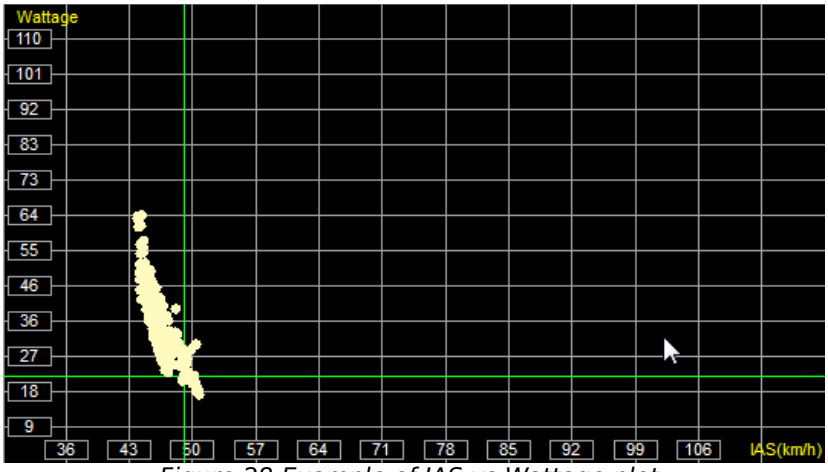


Figure 28:Example of IAS vs Wattage plot

The *Battery data* section shows data about the battery capacity status: the information shown corresponds to the mAh **left** on the battery, and the percentage of battery **left**. For that it is necessary to set the maximum battery Amperage on the *Max [mAh]* box, before the mission starts. With this data is possible to know the amount of consumed battery with an error lower than 3%.

Besides capacity left, there is also a time left estimation. This time estimation is computed using the displayed estimate consumption. The time shown is the estimate to reach 15% of battery capacity left.

Old versions of autopilot may not have a time estimation available as they don't transmit all the necessary information for this estimation.

The reset button present in this dialog resets the consumption counter held on-board the autopilot.

Note: Notice that the maximum capacity must set be in mAh.

Note: This option is only available for the U-Pilot with an amperometer mounted on the battery cables. For further information check the 3.2 Monitoring engine data section on the U-pilot manual.

2.8.7.2 Moscat ME03 electronic injection controlled engine

Whenever the system detects a Moscat ME03 ECU connected and sending data the engine data window will switch automatically to this display (See Figure 29: Moscat ME03 Engine control display). Only when connected to this kind of ECU U-See will show this window.

On the left half of the window the following information is available.

- Engine RPM as measured by the two hall efect sensors: Both sensors should read very similar rpms.
- Cylinder head temperature: Temperature as measured by the thermopairs installed at the cylinder head. While in flight both indications should be very similar. On-Ground functioning may exhibit slight differences.
- Fuel injection status:
  - Current measured fuel pressure
  - Current approximated engine throttle value
  - Total accumulated consumption **in kg**.[16]
  - Instantaneous fuel consumption **in kg/h**
- Manifold pressure and temperature measurement.

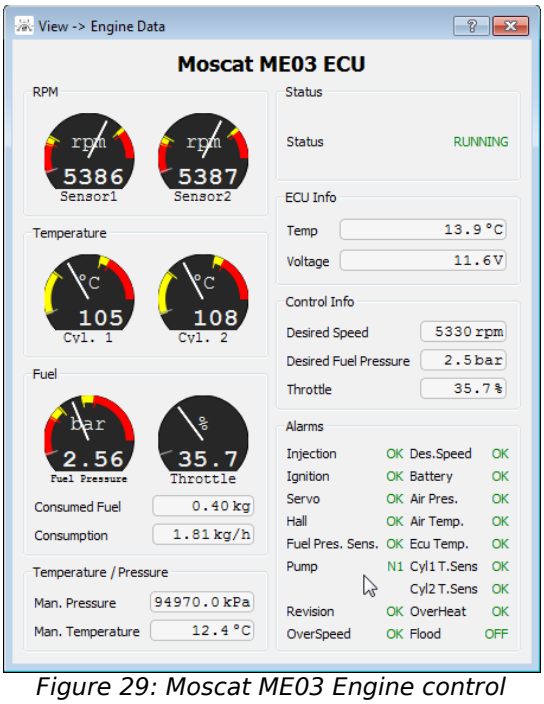


Figure 29: Moscat ME03 Engine control display

RPMs, Temperature and fuel pressure have warning and critical values. Whenever the parameter enters this range, the ENG alarm is triggered in the appropriate level is launched in the alarms panel (See Section 2.8.5.1, Alarms section)

The limits are:

- RPM:
  - Critical: RPM < 1500 or RPM > 6500
  - Warning: RPM < 1900 rpm or RPM > 6000

16 Current version does not support pounds for fuel indication.

- Temperature:
  - Critical: Temperature > 200°C
  - Warning: Temperature < 70°C or Temperature > 180°C
- Fuel Pressure
  - Nominal value is 2.5 bar
  - Critical: Fuel pressure <1.5 bar or Fuel Pressure > 3.5 bar
  - Warning: Fuel pressure < 2.0 bar or Fuel Pressure > 3.0 bar

On the right half of the window, by order, following information is found:

- Engine Status. Possible status are:
  - STOPPED: Engine is not working. The word STOPPED will be red coloured and this state is linked to a critical alarm in the ENG alarm in the alarms panel.
  - CRANKING: Engine is being externally turned. Word will be black-coloured and this state is linked to warning state of the ENG alarm in the alarms panel.
  - WARMING-UP: Engine has been recently started and it is running an automatic warm-up cycle. During this time, the autopilot does not have control over engine RPM and the engine is not ready for flight. This mode will end as soon the mean of both engine temperature indication reaches 80 °C. When in this state, the word WARMING-UP will be coloured in orange and this state is linked to a warning state of the ENG alarm in the alarms panel.
  - RUNNING: Engine is running by its own means and the autopilot has control over it. In this state, the work RUNNING will be green coloured and, if no other problem is found in the engine operating parameters, this is linked to a normal state of the ENG alarm in the alarms panel.
- ECU working condition information: temperature and main voltage value.
- Control information: Values the control is trying to maintain. These values and the measured values should agree.
- Alarms: This subpanel holds the alarms information regarding engine subsystems. Any abnormal condition will be signalled by showing the word FAIL coloured in red and it will trigger a critical alarm state of the alarm ENG in the alarms panel.

2.8.8 Vibration frequency Graphs

Accessed through *View → Vibration Frequency Graphs*, this unique functionality allows you to examine the vibration spectra of your vehicle in real time. With this tool you can clearly see the source of vibration in your system and check if the system vibration is nominal, or, on the other hand, there is a new source of vibration indicative of a failure.

In this window you can see the current state of the three axis vibration pattern, with a bar that scans the different frequencies. On the right hand of every axis you have options to alter the vertical scale (x2, x1, x1/2, x1/4) that will alter the height of a given vibration amplitude.

Also, there is a checkbox titled “LPF”[17]: with it checked you will see the mean of various samples and unchecked will give the immediate result.

17 LPF stands for Low Pass Filter

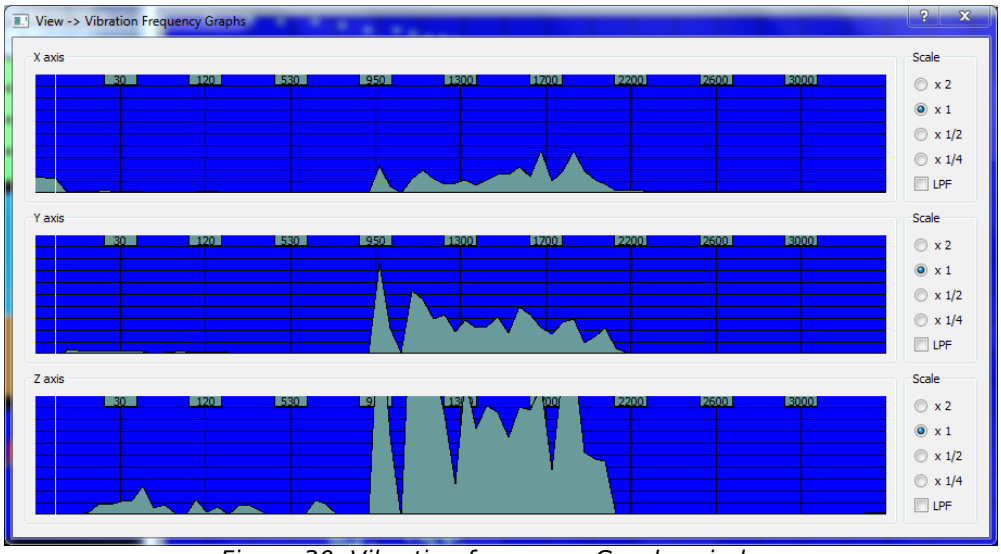


Figure 30: Vibration frequency Graphs window

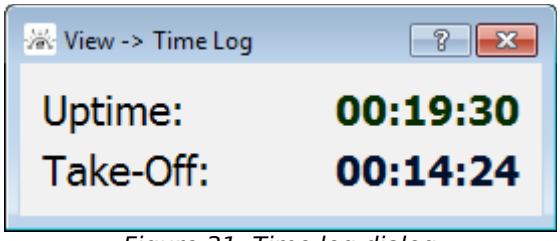


Figure 31: Time log dialog

2.8.9 Time log

This windows shows current uptime as registered by the autopilot. This is the time that has passed since the power-on of the autopilot. This time is always positive and it is monotonically increasing. This time counter only resets at autopilot power-on, so it is an appropriate way to detect power supply problems should they arise.

Take-Off time shows how much time has passed since the **last U-See detected automatic take-off** phase.

This means that this time won't be accurate if:

- The flight is started in manual or semi-manual modes.
- The take-off occurred while the current U-See instance was not running.
- Control handover has occurred and a different UAV is being monitored.

2.9 Pre-Flight Menu

The tools on Pre-Flight drop down menu have to be used before the flight starts, with the UAV on the Runway, with communication with the U-Ground and with GPS signal.

Safety Warning

It is very recommended to set the manual mode and keep the throttle on the joystick to minimum while adjusting the pre-flight parameters to minimize injury risk to persons around the UAV in case the operator makes a mistake.

It is also very recommendable to keep engines or motors turned off until the UAV is ready for flight.

2.9.1 Checklist

Figure 32: Checklist main window

The checklist tool allows the user to run a series of pre-flight checks in order to prevent errors during operation. The checklist widget is able to keep in memory up to 5 pre-designed checklists. The checklists are defined in text files and can be provided by Airelectronics or custom-made by the client.

The checklist main window allows the user to add, remove or run up to 5 checklists. When adding a checklist, the software will ask the user for the location of the checklist file and will notify if there are any problems with the file.

The checklist files must have the following structure.

First Line: checklist Title

Second Line: creation date (DD/MM/YYYY)

Third Line: author (e.g. Airelectronics)

Fourth Line: BEGIN (checklist start mark)

Next Lines: checklist points, one point per line

Last Line: END (checklist end mark)

```
Material Skywalker
04/12/2013
Airelectronics
BEGIN
Point 1 to check
Point 2 to check
…
Point N to check
END
```

Text 1: Example checklist file

When a checklist is successfully loaded, it will appear in the checklist window with the run button enabled. Clicking this button will start the checklist process asking the user if that is the correct checklist to run.

During each check of the checklist, the software will block the “Next” button for a few seconds, preventing the user from skipping points.

Figure 33: Checklist question

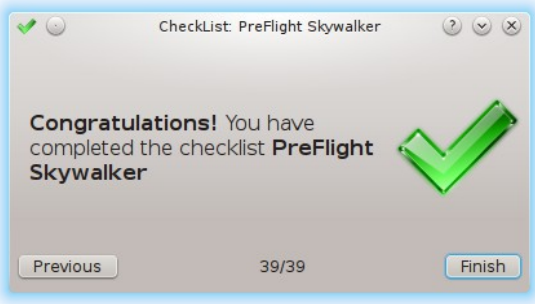


Figure 34: Checklist completion

When the checklist is completed, a green tick will appear with a completion message and a finish button to end the checklist process.

2.9.2 Runway

This tool is used to define the Runway coordinates and altitude. This coordinates can be entered manually or using the reported GPS position. In both cases the orientation of the runway must be defined by the operator. When the Runway is set, a runway icon must appear on the map properly orientated.

To define the Runway follow these steps:

1. Physically place the UAV on the Runway.
2. Check that the GPS signal is correct.
3. Open the Runway window on Pre-Flight → *Runway.*
4. Click on the radio button to enable the Runway settings.
5. Press the *Set current coordinates* or introduce manually the latitude, longitude and altitude.
6. Click the radio button to disable the values introduction and ensure that the coordinates introduced are correctly set up.
7. Click on the radio button to enable the Runway settings.
8. Select the Heading of the Runway manually.
9. Check that the Runway icon is heading the correct direction on the map.
10. Click on *Set* button to send the information to the U-Pilot.

Note: In case that the runway settings have to be saved for posterior flights, changes must be saved on Settings → Save Changes as described in Save Changes section.

2.9.3 Advanced Runway (Optional)

This is an optional feature and may not apply to your U-See version

When available, this dialog allows greater control over the runway location editing process. This dialogs operates in two modes. Display mode and Editing mode. While in display mode, the dialog will only display the current stored and reported autopilot values. No interaction is possible except for clicking the *"Enter edit mode"* button

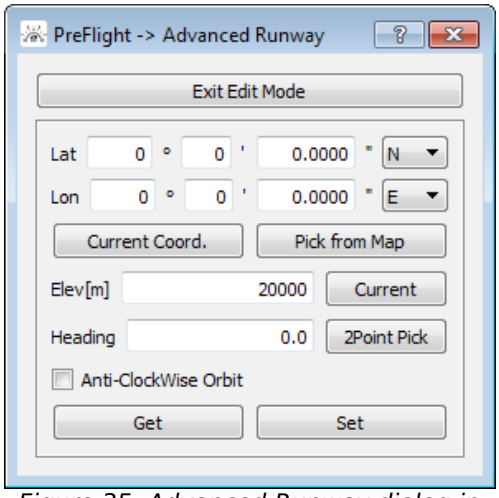


Figure 35: Advanced Runway dialog in edit mode

While in edit mode, it is possible to hand edit the landing site coordinates, set the landing site to the current aircraft position and it is also possible to select a landing site coordinates by map interaction.

When clicking in *"Pick from Map"* all dialogs will hide leaving only map view and a left click on the map will select those coordinates as landing site. Upon click on the map, the landing site icon should be displayed on the clicked position to confirm selection. If not, a click on set will resend the selected coordinates to the autopilot.

It is important to understand that buttons *"Current coord."* and *"Pick from Map"* **only affects landing site coordinates**, this is, landing site altitude won't be changed by these buttons and the user must set both elevation and heading values to appropiate values.

Elevation can be adjusted to current value by clicking "*Current*" button by the input field or by writing a value by hand. **Current button only affects the landing site elevation**

Heading of the landing site can be manually introduced or measured from map through use of *"2Point Pick"* button. Click in this button will hide all windows except the map display and two consecutive left clicks on the map will indicate landing field orientation.

At the bottom of the dialog, above the get and set button a check-box allows to change the direction the autopilot executes the landing hold orbit. Note that this only affects fixed wing aircrafts.

At the bottom of the window the usual get and set buttons will put current autopilot values into the dialog (Get button) or send the current values to the autopilot(Set button)

Safety Warning

Before exiting edit mode verify that the values on-board the autopilot match the values shown on the dialog by clicking "*Get*" button and reviewing the values.

Check that all the necessary parameters have been edited: coordinates, elevation and heading of the landing site.

2.9.4 Flight-Plan

To open the Flight Plan window go to Pre-Flight → *Flight Plan*.

In Flight-plan mode the UAV heads one by one to the defined waypoints. These waypoints are numbered starting with number one. When the last point is reached, the UAV will start the flight plan again from the first point.

Through the menu entry, access is gained to the flight-plan editor.

This flight-plan editor shows and modifies the contents of a Autopilot's memory loaded flight-plan. It will not work at all if there is no communications established with an operating autopilot.

Off-line flight-plan editor is in the works.

When activating “Save Changes” option the active flight-plan is saved into the non-volatile memory of the autopilot and will be available through power cycling.

Flight-plans can also be saved in a “.fp” file using the “Save to a file” option available in the flight-plan editor.

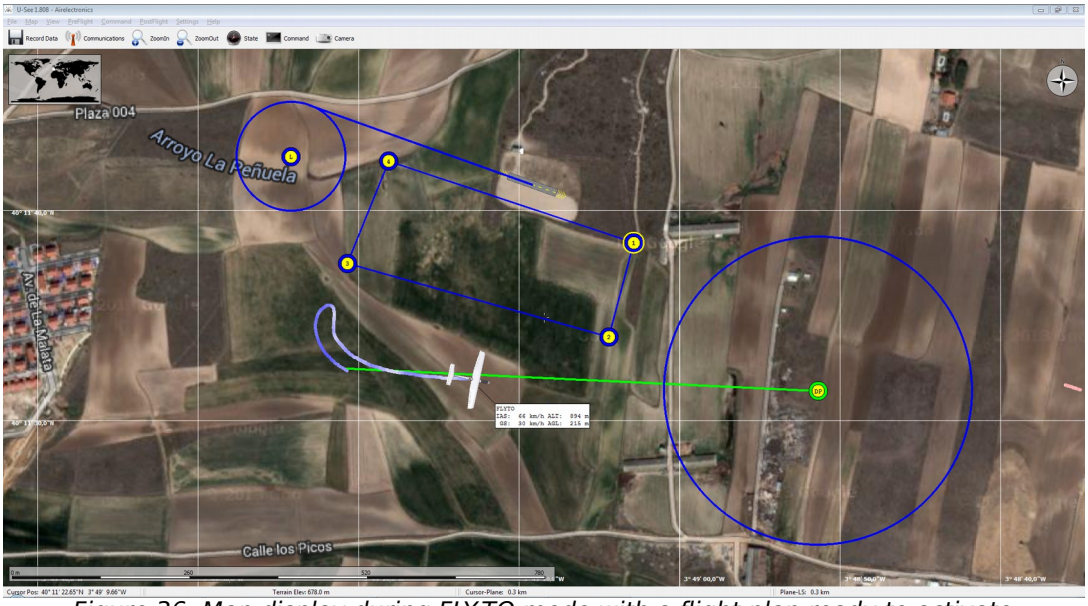


Figure 36: Map display during FLY-TO mode with a flight plan ready to activate

2.9.4.1 Flightplan Editor Window. Display Mode

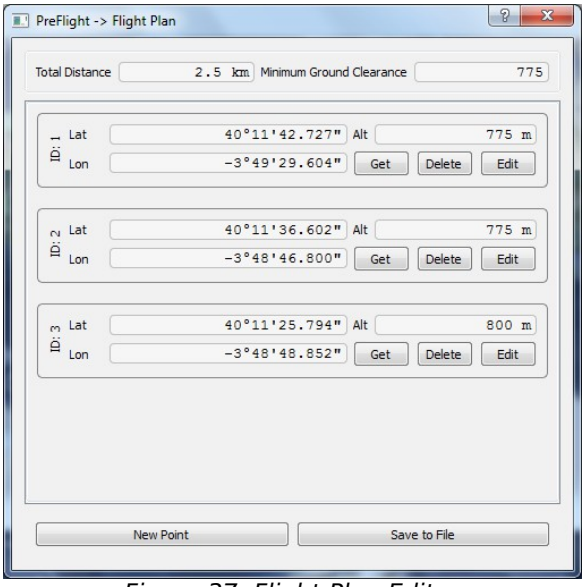


Figure 37: Flight-Plan Editor

The flight-plan editor window has three well separated zones:

- Header of the window: Gives general information about the current flight-plan.
  - Total Distance: On-Ground distance the UAV will have traveled after completing one flight-plan loop (From point one to the last enabled point and back to one)
  - Minimum Ground Clearance: Minimum ground clearance at the way-points[18]
- Body of the window: Current way-points location in coordinates and altitude.
- Footer of window:
  - Add a new point at the end of flight-plan
  - Save to a file current flight-plan

Every row in the body of the window represents one way-point. Besides its coordinates, three buttons are available for every row:

- Get Button: This will query the autopilot for the current values for the way-point. This is usually not required, as autopilot reports sequentially the current state of the way-points automatically.
- Delete Button: This button will delete the selected point and all the following way-points from the flight-plan
- Edit Button: This will put the row in edit mode, changing the way the right click behaves in the map and allowing changes in the way-point data.

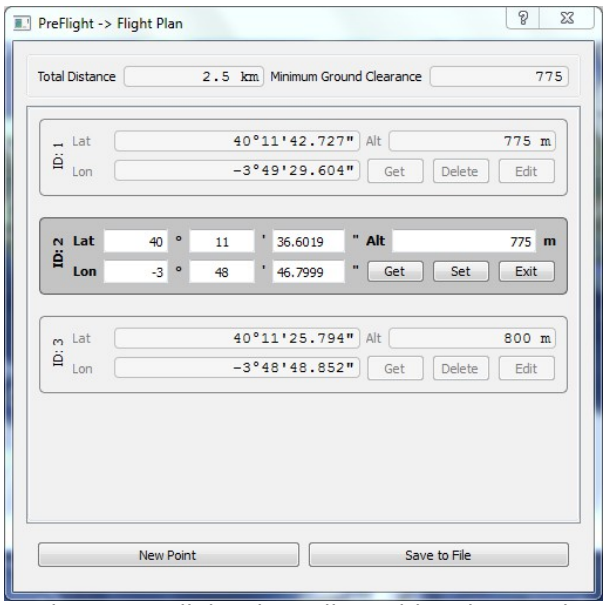


Figure 38: Flight-plan editor with point ID 3 in edit mode

2.9.4.2 Flight-plan editor: Edit mode

When in edit mode, the looks and behavior of the flight-plan editor will change:

Notice how all the rows except the one corresponding point 3 in figure 42 are grayed out, with their buttons disabled.

Also note that the coordinates and altitude field in the row for point id 3 are now editable fields.

Also, while in edit mode, all the windows in the program but the flight-plan editor will hide to allow clear view of the map. Right button click

18 Note that less ground separation could be found in-between points.

will pick coordinates from the map for Point ID 3 position. This change in behavior is shown on the map with a cursor in crosshair form and a tool-tip reading “Right Click Picks ID Point X”

To make changes, edit using the keyboard the coordinates and altitude and click *Set*.

When using the mouse to select coordinates the *Set* button will be automatically engaged after each click. Remember to adjust the altitude when operating with the mouse

Get button will put into the editable fields the current autopilot values for the way-point. *Set* button will try to upload way-point data to the autopilot and *Exit* will exit the edit mode.

After every 'S*et*' or right click in edit mode, the icon displaying the point on the map should have moved to the desired position. If not, just push '*Set*' repeatedly until the point is in position.

Closing the Flight-plan window also exits editing mode.

2.9.4.3 New Point Loading

To add a point to the flight-plan click on “*New Point*”. All windows but the map view will hide temporarily and the cursor will turn into a crosshair. A tool-tip will follow the cursor to remind the change of behavior in the right mouse click. It reads “*Right button appends new ID Point X. Altitude will default to maintain ground clearance*”

After a right click in the desired position, a new point, with incremental ID should be drawn on map and reported in the flight-plan window.

Altitude of said point will be the elevation calculated for those coordinates plus the minimum previous ground clearance. If that's not the desired altitude, it should be edited using the “*Edit*” button

Pressing ESC key in the keyboard while in the new point mode will cancel the operation.

2.9.4.4 Completely new flight-plan procedure

For creating a completely new flight-plan follow the following steps:

1. If a previous flight-plan is present: click on “*Delete*” button for the point ID 1.
2. Click in “Add New Point”
3. Right click in the map for desired way-point position
4. If altitude is not the desired:
    1. click in *Edit*
    2. Change altitude
    3. Click in *Set*
    4. Confirm altitude by clicking in *Get*
    5. Click in *Exit*
5. Repeat 2 through 4 until desired flight-plan is ready.

Note that the flight-plan editor will respect the minimum ground clearance, so for a constant AGL altitude flight-plan the operation will be considerably simplified:

1. If a previous flight-plan is present: click on “*Delete*” button for the point ID 1.
2. Click in “Add New Point”
3. Adjust altitude to provide desired clearance in point 1

4. Just add following points without worrying about altitude.

Note: Flight Plan points are edited one at a time. This way it is easier to upload and download the information and the communications are not overloaded.

Note: The Flight Plan points must start on number one. The following flight points must increase its number by one each time.

Note: If the flight plan created must be saved for posterior flights, the changes must be saved on Settings → Save Changes as described on 8.7.4 Save Changes.

2.9.5 Bingo Time

Bingo[19] time is a prefixed amount of time, that once surpassed will trigger a return home in the autopilot.

To define this time, select *Preflight → Bingo Time*. In the dialog, enter the desired amount of time and the unit this time is expressed in (See Figure 39: Bingo time window) from the drop down menu and click on *Set.*

When the bingo time is set, an automatic bingo count down appears on the Bingo alarm on the *Alarm window* (See 2.8.5.1 Alarms section)set as green. In case the bingo time arrives to zero, the bingo alarm will change to red with the word “BINGO” on it.

The operator can override this return home by commanding any other mode, however, have in mind that until the Bingo time counter is reset, U-Pilot won't attempt another automatic return home once it has been over-commanded.

A click in *Disable Bingo* will stop the count-down, disarm the BINGO alarm and deactivate auto-return home by time.

This tool is not mandatory for flight but recommended.

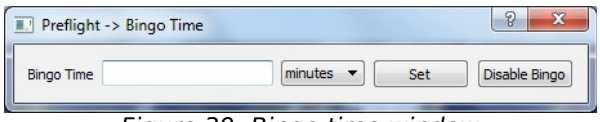


Figure 39: Bingo time window

2.9.6 Pattern Generator

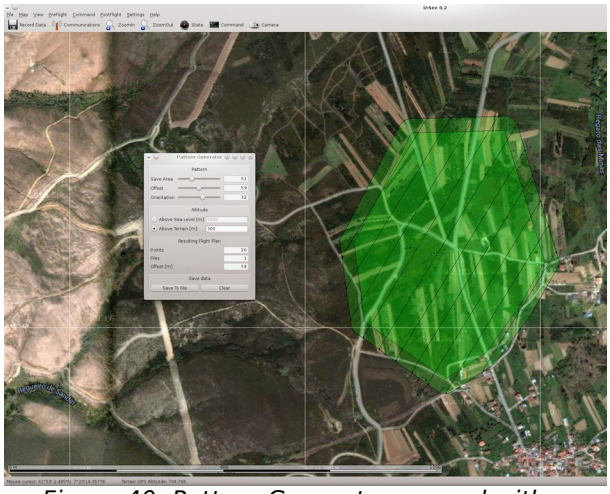


Figure 40: Pattern Generator opened with a declared field for survey.

This tool is intended for use with terrain observation flights that require covering some part of the terrain in an exhaustive manner. By declaring (through right click) the external outline of the desired surveyed terrain this tool will generate a set of files describing the proper pattern flight-plan to cover the terrain.

2.9.6.1 Intended use

Unlike the usual tools included in U-See, this part of the program does not require a connected autopilot. We recommend to use this tool before deploying to the field, leaving the files prepared for upload once ready for operation.

19 Bingo is the code word used in OTAN standard radio brevity code to indicate fuel levels on-board have reached levels that recommend a return to the base.

2.9.6.2 Use of pattern generator

To access pattern generator, select *Pre-Flight → Pattern Generator.* The pattern geneerator window will open and the right button click on map will change functionality.

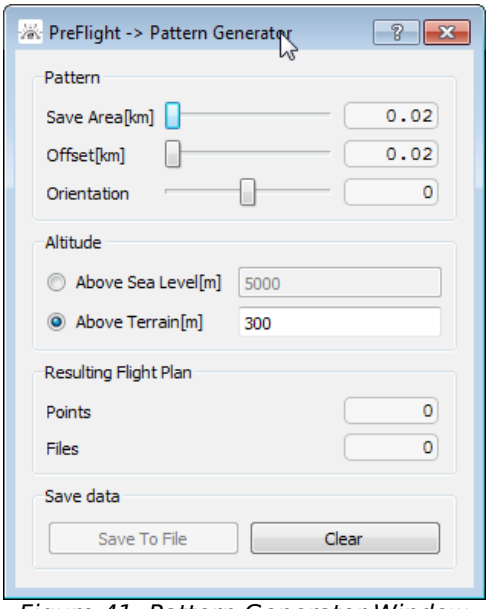


Figure 41: Pattern Generator Window

The basics of the pattern generation is the marking of the desired observation field.

This is accomplished by means of right mouse button clicks. Every time a right click is made, a vertex is added to the observation polygon. As many as needed vertices can be added to the polygon, although it is necessary to add the vertices in order to avoid self intersecting polygons.

Polygon will be drawn once you have more than three points marked and it will get updated while points are added. Desired survey polygon will be drawn using intense translucid green color. Save area will be drawn in a darker green color and projected navigation legs will be drawn as black lines.

If an error is made, the *clear* button will clear the points defined up to the moment and will reset the area to start again.

2.9.6.3 Available parameters.

Once declared the desired survey field, a handful of parameters can be adjusted to fine-tune the generated flight-plan.

- Save Area: UAV needs a non-negible space for making turns, this means that the final and starting parts of every navigation leg would received bad coverage by the cameras on-board as the UAV is still trying to manoeuvre to get into position. Save area parameters controls a grow in the area surveyed to assure the UAV is well stablished on navigation leg when it reaches the area of interest.
- Offset: This parameter controls the lateral separation of the navigation legs.
- Orientation: It controls the geograhic bearing that will be used to fly over the disgnated survey area.
- Altitude: How high the overfly will be made. There are two modes for generating the flight-plan point altitudes:
  - Above Seal Level
  - Above the terrain.

The “Resulting flight plan” informational display shows how many flight-plan points will be needed for covering the desired field, how many flight-plan files the tool will generate and the lateral separation of navigational legs in meters

Zoom level of the map will affect the effective lateral separation of the navigation leg generated. This is because the tool works on screen coordinates and generates geographic coordinates when writing to file.

AGL information is calculated using a Digital Elevation Model (DEM for short) incorporated into U-See.

Default DEM used in U-See has global coverage but, in exchange, its accuracy at some points may be lacking. Errors as high as 150 m. can exist.

Because of this, we advise to review carefully the generated flight-plan once it is loaded in the autopilot for proper ground clearance.

This warning still applies if high detail DEM is loaded instead of U-See default: DEMs usually do **NOT** include obstacles (as buildings and antennas) and terrain may have changed since the DEM preparation date because of human development.

2.9.6.4 Saving results

Once the parameters have been adjusted, it is necessary to save the results to disk for later usage. Such thing is accomplished by clicking on "*Save*" button. A dialog will open in which a base name and location should be given for the flight-plan files.

The name given in the dialog will be suffixed with a sequence number and the ".fp" file extension.

For instance, if a particular area defined needs 67 flight-plan points and the filename given is "example" the program will save in the selected directory the following files:

- example-01.fp (Containing flight-plan points 1 to 32)
- example-02.fp (Containing flight-plan points from 33 to 64)
- example-03.fp (Containing flight-plan from 65 to 67)

These files should be loaded on the autopilot using the "Flightplan from File" found in the pre-flight menu. (See following section)

2.9.7 Flightplan From File

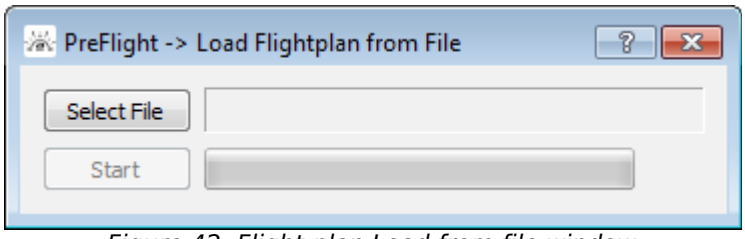


Figure 42: Flight-plan Load from file window

This dialog will allow the selection of a ".fp" flight-plan definition file and upload it to an active connected U-Pilot autopilot.

Once the button start is clicked, the program will check the syntax of the file and will start uploading the flight-plan points information one by one.

If any problem shall arise during the upload, an informational dialog will be presented informing the nature of the failure and the proper corrective action to take.

2.10 Command Menu

2.10.1 Command window

To open the Command window click icon or go to *Command → Command.*

The software automatically recognize if the vehicle is fixed wing or rotary wing and will present the proper command window.

On the main map screen, all the information regarding the current mode will be shown in green and all the information that the current mode is not using will be shown in blue. For example if the UAV is in Take-Off mode, the flight plan path will be shown in blue but as soon as the operator will click the Flight Plan button the flight plan path will become green.

This is the primary window during an actual flight mission.

2.10.1.1 Fixed wing command window

The fixed wing command window is divided in two groups

- The command modes group where the command buttons are shown, grouped by flight modes categories:
  - Flight modes: Normal flight modes
  - Special Modes: Modes used in special vehicles, special circumstances or used only in very specific moments.
  - Non-Flight modes: Modes that may pose danger for the aircraft if commanded while in-flight.
- When available (optional Autopilot feature), an aditional row of buttons will be displayed, reading “NORMAL” and “ECO”. See 2.10.1.2 Normal and ECO flight laws.
- The Altitude, Velocity and Orbiting radius setting menu. The operator can select the Altitude, Velocity and Orbiting radius on each flight mode. To do so the operator must enter the new values on the corresponding box and click *Set* button. Orbiting is only available for fixed wing UAVs and it is not available for rotary wing UAVs
  - When available (optional AP feature) and additional item will show: Vertical Performance. See 2.10.1.3 Vertical Performance limits.

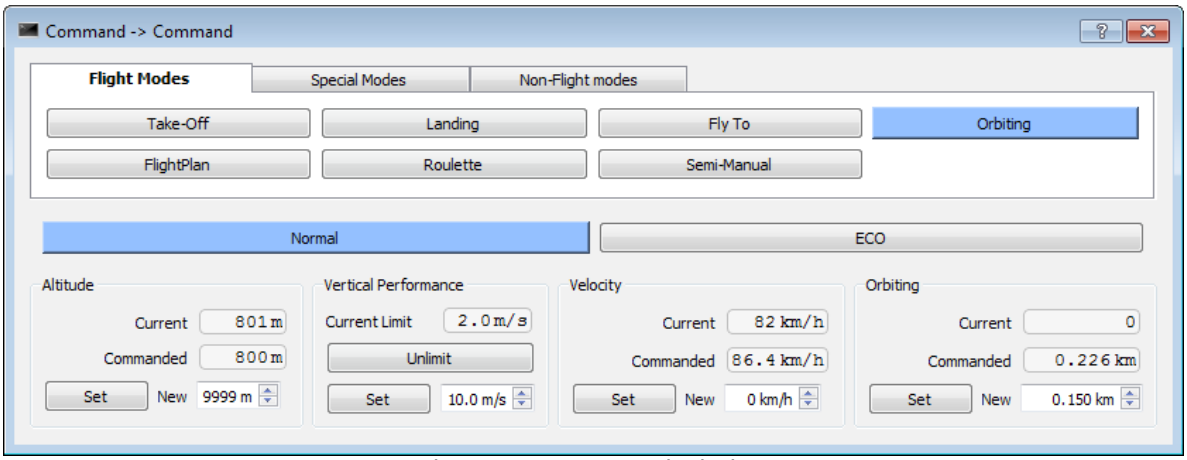


Figure 43: Command window

Note: Each UAV has a flight envelope which restricts flight speed commands to minimum and maximum values. Values out of this restriction are not accepted by the U-Pilot. Flight envelopes may change for each flight mode and are pre-configured by Airelectronics, the end user does not have to worry about it.

2.10.1.2 Normal and ECO flight laws

Optionally available for fixed wing vehicles only, it is possible to change the speed and altitude holding strategy. This settings is independent of flight mode, but not all modes allow command of Economic flight law. Whenever the user changes the mode, the flight law will reset to normal.

Current flight law will be indicated by a blue background in the currently active flight law button. Modes that do not accept change of flight law will have both buttons disabled.

Economic flight law will introduce a strategy in which speed is controlled by pitch angle and altitude is controlled by throttle command. This will reduce altitude holding accuracy, but, in exchange, throttle command will be executed much more slower.

Additionally, autopilot will not correct altitude errors in the positive, i.e. if the autopilot is higher than commanded the throttle will be cut to reduce consumption, but not further action will be taken.

Economic flight also enables gliding navigation and thermal soaring through the orbiting mode combined with economic flight law.

However, as the altitude control is not as accurate, it should not be activated whenever near the ground or when flying in airspace that requires strict vertical separation levels.

2.10.1.3 Vertical Performance limits

Optionally available autopilot feature. It may not apply to your software/autopilot pair. Through this setting, vertical transition climb and descend can be limited. Current limit is displayed in the selected vertical climb units or “Unlimited” is shown.

When operating unlimited or with a too high limit, the autopilot flight envelope limitations still apply and transitions will be executed at maximum pre-configured safe values.

2.10.1.4 Available Fixed Wing Modes description

2.10.1.4.1 Manual mode

At this flight mode U-Pilot gives all the control to the external pilot.

This mode must be selected before the mission starts in order to do the Pre-Flight settings. Be aware of the throttle stick specially in electric motors.

2.10.1.4.2 Semi-Manual

In this mode the manual pilot input commands will be interpreted as requested attitude angle, instead of requested surface deflection. **Autopilot will only control attitude angles while in this mode, so it is responsibility of the manual pilot to maintain safe altitude, safe flight speed and proper navigation.**

2.10.1.4.3 Fly To mode

At this flight mode the UAV heads a destination point selected by the Computer Operator, the destination point can be changed on real time just right clicking on the map.

Have in mind that if you have the “Flight plan editor” window opened, the right click will be associated to flight plan waypoint set, and it won't change the Fly To point (indicated on the map with a circle with “DP” in it).

When the destination point is reached the UAV automatically goes to orbiting mode using the destination point as orbiting point.

In this mode is possible for the Computer Operator to set the commanded orbiting radius, the commanded speed and the commanded altitude. To define new values of altitude, speed or radius it is required to write the new value on the corresponding box and then click *Set* button.

2.10.1.4.4 Orbiting mode

At this flight mode the UAV orbits a the current position, it will use the current point as orbiting point.

In this mode is possible for the Computer Operator to set the commanded orbiting radius, the commanded speed and the commanded altitude. To define new values of altitude, speed or radius it is required to write the new value on the corresponding box and then click *Set* button.

If the computer operator click with the right button on the map, the UAV will orbit around the point he has clicked. If it turned out that this new point is too far away, the system will change its mode into Fly to mode, and again, will switch into Orbiting mode when close enough.

2.10.1.4.5 Landing mode

The UAV changes its mode to landing in three cases:

- The Computer Operator clicks on Landing Button.
- The Preflight Bingo Time is reached.
- There is a Communication failure between the U-Ground and U-Pilot.

It is mandatory to properly set the Runway checking its altitude and Heading before taking-off. In case of a communication failure the UAV will automatically go to this point.

The landing path is automatically recalculated with all the parameters set to the UAV requirements, the user do not have to worry about it.

Landing path has 4 stages. The UAV will go through this sequence automatically:

- **Return**. The UAV flys towards the hold center point, designated “L” on map. Related to the runway this point is located backward to the right.
- **Hold**. The UAV starts an orbiting mode where adapts its velocity and altitude to start the final landing part. The UAV will turn this path as many times as necessary until it is ready to start the Final path. This turn is done by default clockwise, but turn direction can be adjusted through the advanced runway menu (see 2.9.3 Advanced Runway (Optional))
- **Final**. When the UAV trajectory reaches the tangent direction to the Runway the UAV checks the speed and altitude and if they are correct it will start the final landing part. It will start decreasing its altitude until it is over the threshold of the runway
- **Flare**. Once the Runway threshold is reached, the UAV will carefully rotate to pitch up and it will cut down the throttle, in this controlled position it will touch the ground.

2.10.1.4.6 Roulette mode

On Roulette mode the UAV roll is controlled by the External Pilot with a roulette on the top right of the Futaba Joystick.

The U-Pilot still controls the altitude and speed. The Computer Operator can command a new altitude or speed.

2.10.1.4.7 Flight Plan mode

On this mode the UAV heads one by one different defined points. These points are numbered starting with number one, when the last point is reached the UAV will start the flight plan again from the first point.

Each point is defined by its coordinates and by its altitude.

It is better to establish the flight plan before the mission start, but it is possible to edit it during the flight.

To change these points follow the same procedure described on section 2.9.4 Flight-Plan

2.10.1.4.8 Take-Off mode

On Take-Off mode the UAV starts the take-off maneuver at maximum throttle and increases the altitude.

The take-off heading is set by the operator on the Runway Heading.

Once the UAV reaches a safe altitude the Computer Operator can change its mode.

Default Autopilot version will not end Take-Off phase until told so by the operator with a mode change.

Automatic end of Take-Off is an optional feature that has to be enabled by Airelectronics's upon request. Contact us for information.

Until a valid GPS fix has been established it is not recommended to start the flight.

2.10.1.4.9 Catapult Armed mode

This mode prepares the aircraft for a catapult-driven take-off. Aircraft will try to maintain wing level and pre-configured pitch angle during launch. This mode will not command throttle until a pre-configured amount of time has passed with movement being detected. This allows bungee launching of electric UAVs without harm for propeller damage to the person launching the plane.

2.10.1.4.10 Net landing mode

Net landing is a special mode, so it may not be available for your Software/autopilot version.

Commands the autopilot to land using net recovery mode in moving base mode. The aircraft will cycle through the same stages that for conventional landing: Return, holding and final, but the final target will the net location as indicated by the moving base antena. Vertical offset of the target has to be established through the "*Gains adjustment*" setting entry (See 2.12.1 Gains adjustment (Optional)).

In case the net threshold is crossed and the vehicle has not stopped, autopilot will execute ABORT manoeuvre automatically.

This mode may not be available in your software version.

2.10.1.4.11 Abort

Execute pre-programmed net landing approach manoeuvre. Parameters of the manoeuvre are adjusted using the "*Gains adjustment*" setting entry (See 2.12.1 Gains adjustment (Optional)). It may not be available for your version.

2.10.1.4.12 S-FlyTo (Subordinate fly-to)

Equivalent to conventional fly-to, but destination point will be continuously automatically updated to maintain relative geometry to the moving base. This mode may not be available in your software version.

2.10.1.4.13 L-TAKEOFF (Learning Take-Off)

Only available for hand-launched aircrafts. Equivalent to normal take-off, but this mode will set the landing site position, elevation and heading to the point and direction in which the operator initially launches the aircraft. This mode may not be available in your software version.

2.10.1.4.14 Come Above

Commands a return to the vertical of the landing site and an orbit upon arrival. If the commanded altitude is lower than initial approach altitude, autopilot will climb at least until this altitude. This mode may not be available in your software version.

2.10.1.4.15 Servos Adjustment mode

This mode is used to adjust the mechanical maximum, minimum and neutral position of the servos. It is detailed on Servos. This mode must not be commanded in flight as the servos are effectively disconnected from the autopilot.

2.10.1.4.16 Internal Loops mode

This mode is used to test autopilot reaction to change in attitude and proper surface functioning. U-Pilot will deflect the surfaces trying to maintain pitch 0 and roll 0. This mode does not run the engine (Unless told so by the manual override in the futaba joystick) and can be used for pre-flight aircraft check. This mode must not be commanded in flight as it lacks navigation, speed and altitude control.

2.10.1.5 Rotary wing Command Window

To open the Command window click icon or go to *Command → Command.*

The rotary wing command window is divided in two groups

- The command modes group where the command buttons are shown, the user can set the current flight mode.
- The Altitude and Speed setting groups. Current and commanded values are displayed here. Besides, an input box is displayed to set new commanded values. To do so, write a new value and push *Set*. Written value should be displayed now in the *commanded* display Notice the lack of orbiting radius command, as it is not used in rotary wing aircrafts.

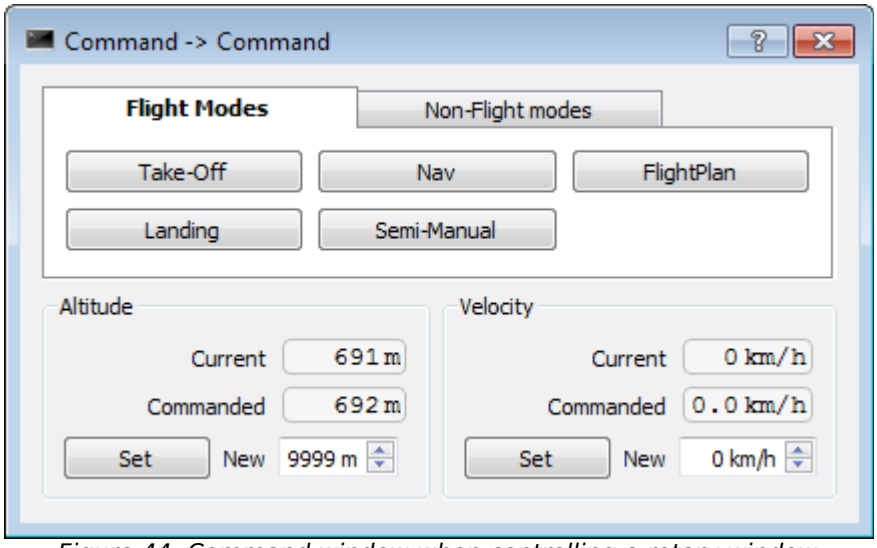


Figure 44: Command window when controlling a rotary window

Note: Each UAV has a flight envelope which restricts flight speed commands to be bound between a minimum and maximum value. Values out of this restriction are not accepted by the U-Pilot Autopilot. Flight envelopes may change for each flight mode and are pre-configured by Airelectronics, the end user does not have to worry about it.

2.10.1.6 Available modes for the Rotary Wing UAVs

We recommend you to take a look at our "Video Tutorials" section in our web page (www.airelectronics.es) to see the system working and to better understand available modes.

2.10.1.6.1 Manual mode

In this flight mode the U-Pilot Autopilot gives control to the external pilot but still assists the external pilot, specially with the heading of the UAV, acting as an advanced gyroscope, making the system more controllable for a human operator.

This mode must be selected before the mission starts in order to do the Pre-Flight settings. Be aware of the throttle stick specially in electric motors.

The external pilot can always command Manual mode by setting the Futaba Joystick Switch B to "Switch Down position". This switch is located on the top left of the Joystick., this will overrun any mode change from the Computer Operator.

The U-Pilot Autopilot will rest in Manual mode and it will not be possible to change it until the Switch B will be moved to "Switch Up position"

2.10.1.6.2 Take-Off mode

On Take-Off mode the UAV will start climbing and it will increase the altitude at a specified preset vertical speed.

The take-off heading is set by the operator on the Runway Heading.

Once the UAV reaches a safe altitude it will automatically switch to Navigation mode.

Until a valid GPS fix has been stablished it is not recommended to start flying.

Just before commanding Take-Off mode the External Pilot must move the throttle stick of the Futaba joystick up until the UAV is almost flying, then the Computer Operator will click on Take-Off button. (Leave the throttle stick in that position until the Landing is over)

2.10.1.6.3 Navigation mode

On this flight mode the UAV keeps its position and altitude at a destination point. The destination point can be changed on real time just right clicking on the map. When the destination point is reached the UAV keeps this position.

In this mode is possible for the Computer Operator to set the commanded speed and the commanded altitude. To define new values of altitude or speed it is required to write the new value on the corresponding box and then click *Set* button.

Notice than if the commanded speed is equal to 0 the UAV will not change its position.

2.10.1.6.4 Flight Plan mode

On this mode the UAV heads one by one different defined points. These points are numbered starting with number one, when the last point is reached the UAV will start the flight plan again from the first point.

Each point is defined by its coordinates and by its altitude.

It is better to stablish the flight plan before the mission start, but it is possible to determine it during the flight or even to edit, delete or add points.

To change these points follow the same procedure described on section 7.3.6 Flight Plan

2.10.1.6.5 Landing mode

The UAV changes its mode to landing in three cases:

- The Computer Operator clicks on Landing Button.
- The Preflight Bingo Time is reached.
- There is a Communication failure between the U-Ground and the U-Pilot Autopilot.

It is mandatory to properly set the Runway checking its altitude and Heading before taking-off. In case of a communication failure the UAV will automatically go to this point.

The landing path is automatically recalculated with all the parameters set to the UAV requirements, the end user do not have to worry about it.

The UAV will return to the Runway Point at a safe altitude, once this point is reached, it will command UAV commanded yaw equal to the Runway Heading and it will start descending at a controlled rate.

Once the Ground has been reached and the UAV has landed, the External Pilot must kill the engine and then move the B switch to down position, taking control in Manual mode and then disconnecting power.

2.10.1.6.6 Servos Adjustment mode

This mode is used to adjust the mechanical maximum minimum and neutral position of the servos. It is detailed in Servos section.

This mode shall never be commanded while in flight, as it disconnects servos from the autopilot control.

2.10.2 Camera command window

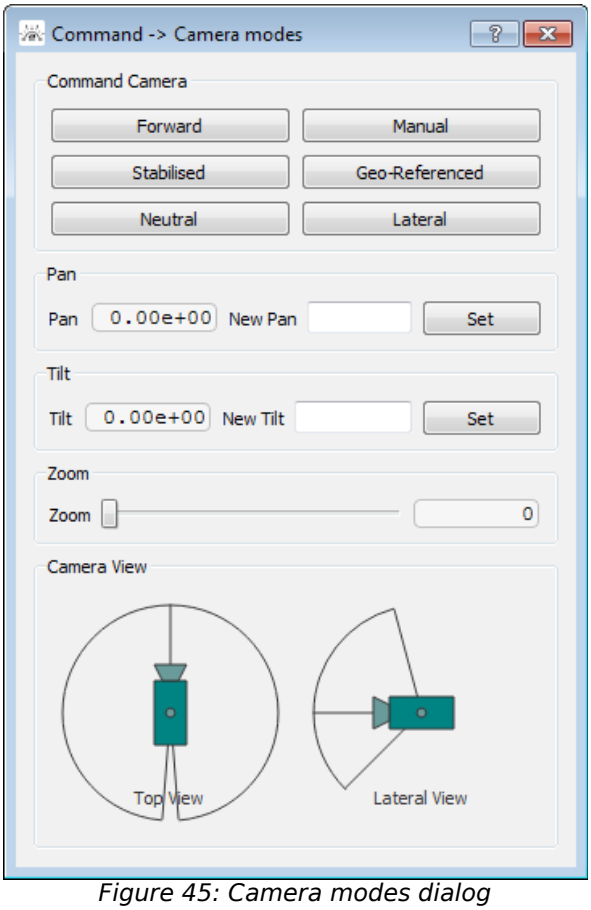


Figure 45: Camera modes dialog

In this window you can command the available on-board camera pointing capabilities of U-See.

In this window you can command the different modes available for the camera pointing:

- **Forward**: Camera will point directly forward. No change in orientation is permitted
- **Manual**: The camera can be adjusted to whatever Pan and Tilt you wish through the text editing boxes. Camera will point in this direction regardless the vehicle orientation. The orientation of the camera may be changed in this mode through a dedicated joystick connected to the computer or entering directly the desired pan and tilt value in the input boxes.
- **Stabilised**: The camera will maintain spatial orientation of the current selected pan and tilt. If the vehicle rises its nose, the camera will correct the movement to continuing looking at the same spatial direction. Although it will not follow a particular sub-vehicle point. The orientation of the camera may be changed in this mode through a dedicated joystick connected to the computer.
- **Geo-Referenced**: In this mode the camera of the vehicle will be pointed towards the point designated through left click on the map. The camera will correct attitude changes and position changes in the vehicle to always look to the coordinates selected. The hardware will use a Digital Elevation Model (DEM) to keep track of the ground while climbing or descending. The orientation of the camera may be changed in this mode through a dedicated joystick connected to the computer.
- **Neutral**: Camera actuators will be instructed to adopt their neutral position.

- **Lateral:** Special mode for one-axis roll mounted cameras. This mode keeps a fixed angle with the horizon and enables stable observation of a on-ground point while in orbiting with a considerably lighter and simpler camera setup.

Besides, you can command the zoom level of the camera through the slider.

2.10.3 Landing Control window (Optional)

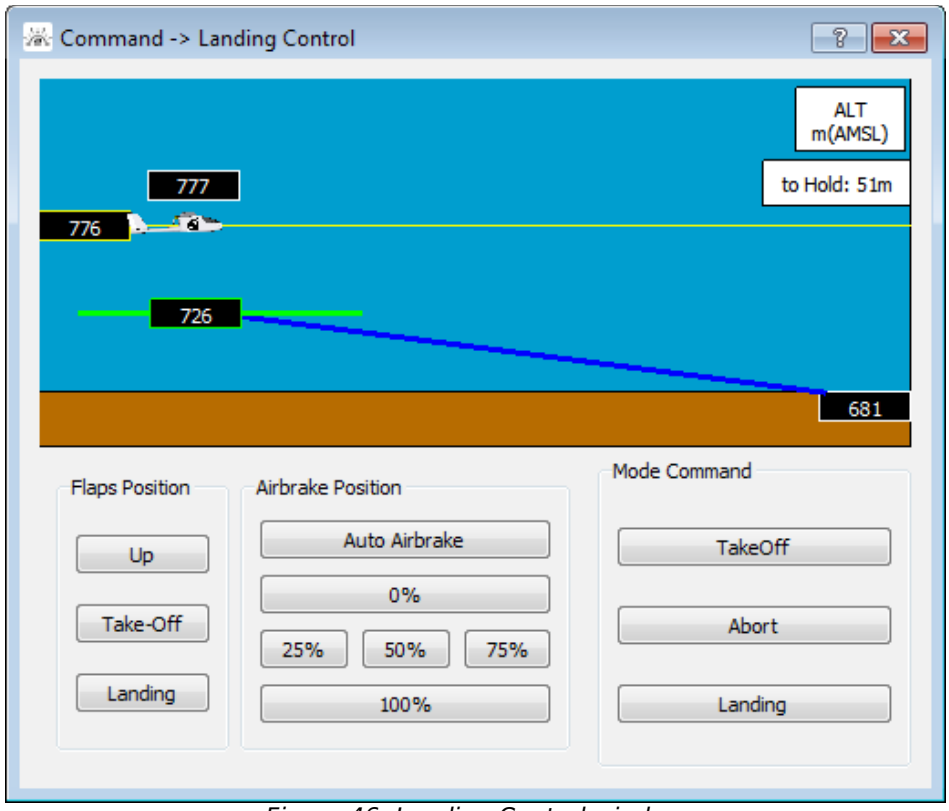


Figure 46: Landing Control window

Designed for fixed wing landing operation, this window won't be available. while operating a rotary wing aircraft.

The window is designed to reduce clutter interface while in landing phase by showing only landing related commands and information.

This windows is composed of a profile view of the landing manoeuvre. It will show current aircraft position and altitude, the current commanded altitude (Yellow horizontal line) and hold level altitude, besides field landing elevation.

Below the profile display, an embedded version of the command aux surfaces is available. This allows manual override of the flaps and airbrakes in the aircraft.

Mode command is also available, with only landing-relevant modes available with the buttons located at the right bottom corner.

When in final approach mode, a progress bar will show how many meters are left for the flare phase and an extra button to force flare mode will be displayed.

2.10.4 Command Aux Surfaces

U-pilot has its own algorithms to control the flaps and spoilers during the take-off and landing. There is also a U-Pilot available configuration in witch flaps are controlled manually by the operator, in that case the flaps must be controlled using the *Command Aux Surfaces* window on *Command → Command Aux Surfaces.* On that windows there are tree possible flap positions to be chosen by the operator at any time.

From this window, the user can also handle airbrakes adjusting its position or leave them in automatic for the autopilot to control.

Selecting any other position than “Auto Airbrake” will force the airbrakes to remain in that position and autopilot won't change its position under **any circumstance.** Under normal operating conditions, airbrakes should remain in automatic position.

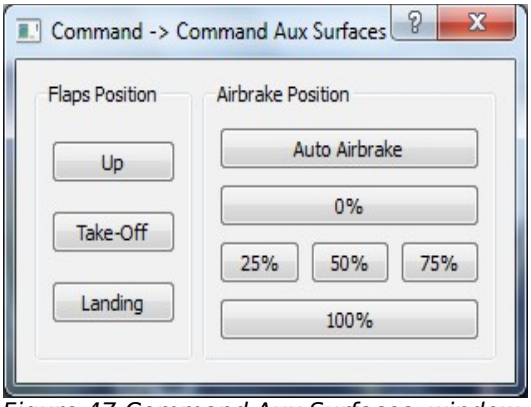


Figure 47:Command Aux Surfaces window

2.10.5 Engine management

Engine management window offers the possibility to inhibit the engine of the UAV. While being active, this option ensures that the autopilot (which is constantly controlling the engine) does not start the engine.

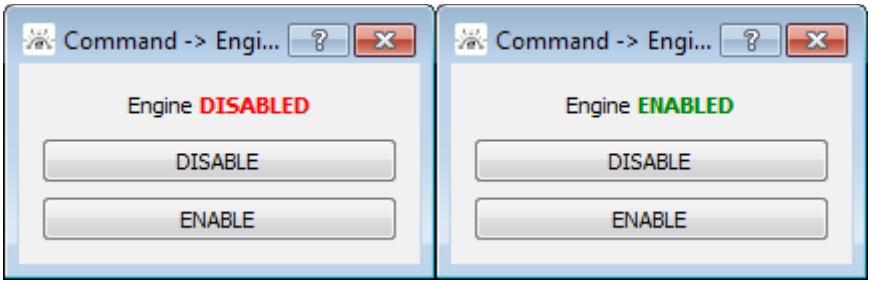


Figure 48: Engine management window

The inhibit feature is intended to be used while UAV is on ground, in the pre-flight phase, while checking everything is correct. This option should be deactivated before flight begins.

Activating or deactivating the inhibit option is dangerous while in flight phase, therefore this option must NOT be used once UAV is flying.

If you wish to know if your autopilot supports this additional feature, please check your autopilot version or contact us.

2.11 Post-Flight Menu

This menu contain options to analyze the data collected from an actual flight. The operations contained in this section do not require communication to a U-Pilot

2.11.1 Record Data → .txt

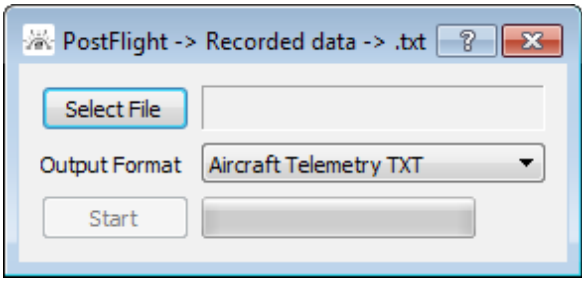


Figure 49: Recorded data->.txt Window

This window is used to transform the binary-only telemetry files recorded on the Record Data dialog to different (usually) text-based formats.

The window presents a button for selecting a binary telemetry file and an output format selector.

Once the Start button has been clicked, the conversion will start converting the file to the selected format. The text-version file will be located in the same directory than the selected binary file, so it is necessary that the file is located in a write-accessible location.

2.11.1.1 Current available formats:

2.11.1.1.1 Aircraft Telemetry TXT

This format exposes the main variables of the flight in a text file suitable for analysis with Microsoft Excel, LibreOffice/OpenOffice Calc, Matlab and similar.

The filename will be that of the binary telemetry file appended with ".txt"

The information contained into this file is structured in 20 columns, separated by tabulator character and end of line is marked using \r\n special characters, according to this table:

Data	Units
Pitch	[Degrees]
Roll	[Degrees]
Yaw	[Degrees]
Commanded Pitch	[Degrees]
Commanded Roll	[Degrees]
Commanded Yaw	[Degrees]
ADC Channel 1	[Volts]
ADC Channel 2	[Volts]
ADC Channel 3	[Volts]
ADC Channel 4	[Volts]
Altitude	[meters]
latitude	[Degrees]
longitude	[Degrees]
IAS	[km/h]
Ground Speed	[km/h]
Commanded IAS	[km/h]
Commanded Altitude	[m]
Speed North	[km/h]
Speed East	[km/h]
Speed Down	[km/h]

Table 5: Data exported for analysis available to the end user

2.11.1.1.2 Camera shots position file TXT

This expansion format is intended for post-process of topography and agriculture studies flights. It will export the main information regarding camera shoots coordinates, plane attitude and time of the shoot.

The filename will be that of the binary telemetry file appended with "_Pointing_coordinates.txt"

Every line in the file is the position of a camera shoot.

The information contained into this file is structured in 18 columns, separated by tabulator character according to the table 6. End of line is marked by \r\n special characters.

Data	Units
Aircraft Pitch	[Degrees]
Aircraft Roll	[Degrees]
Aircraft Yaw	[Degrees]
Aircraft Latitude	[Degrees]
Aircraft Longitude	[Degrees]
Aircraft Altitude	[Meters]
Camera Pan	[Degrees]
Camera Tilt	[Degrees]
Camera normalized pointing vector in horizontal frame. North component.	[0-1]
Camera normalized pointing vector in horizontal frame. East component.	[0-1]
Camera normalized pointing vector in horizontal frame. Down component.	[0-1]
Camera Pointing target Latitude	[Degrees]
Camera Pointing target Longitude	[Degrees]
Camera pointing target elevation.	[Meters]
UTC_hour	[Hours]
UTC_minutes	[Minutes]
UTC_seconds	[Seconds]
TimeStamp[20]	[seconds]

Table 6: Data exported for analysis available to the end user

2.11.1.1.3 NMEA

Telemetry file will be converted to standard NMEA 0803 message lines. Due to limitations in the NMEA protocol for UAV applications, only position information will be written through $GPGLL and $GPGGA messages.

The filename will be that of the binary telemetry file appended with “_NMEA.txt”

For information about the structure of these message, check NMEA 0183 specification

20 This is the uptime value (See section 2.8.9 Time log) of the autopilot when the photo was taken. Its resolution is about 1 ms, so it should be much more accurate than UTC_seconds.

2.12 Settings Menu

Under settings menu, options regarding U-See preferences, customization and hardware setup are available.

2.12.1 Gains adjustment (Optional)

This is an optional feature, so this section may not apply to your U-See version

Some versions of U-See expose a limited amount of parameters for end-user adjustment. The adjustment of these parameters is done through this section of the software.

A wrongful change of this parameters can cause the autopilot to be unable to control the vehicle and the utmost care and attention is necessary when making changes.

By clicking on the left icons a group of parameters concerning a feature can be adjusted. Relevant parameters for the feature selected are shown in the right pane of the dialog.

Each parameter shows its name, the value the parameter had the first time it was received through a get, the current value and the relationship between those two values. Notice the "first time value" is the value the parameter it had the first time it was received in the current U-See session. Consider the following sceneario:

- A get is executed and a parameter has value 1.0
- A set is performed that establish parameter as 2.0
- The relationship will be shown as 200%
- U-See is closed
- A get is executed and now first received value is displayed as 2.0

First value does not represent neither a default nor necessary safe value.

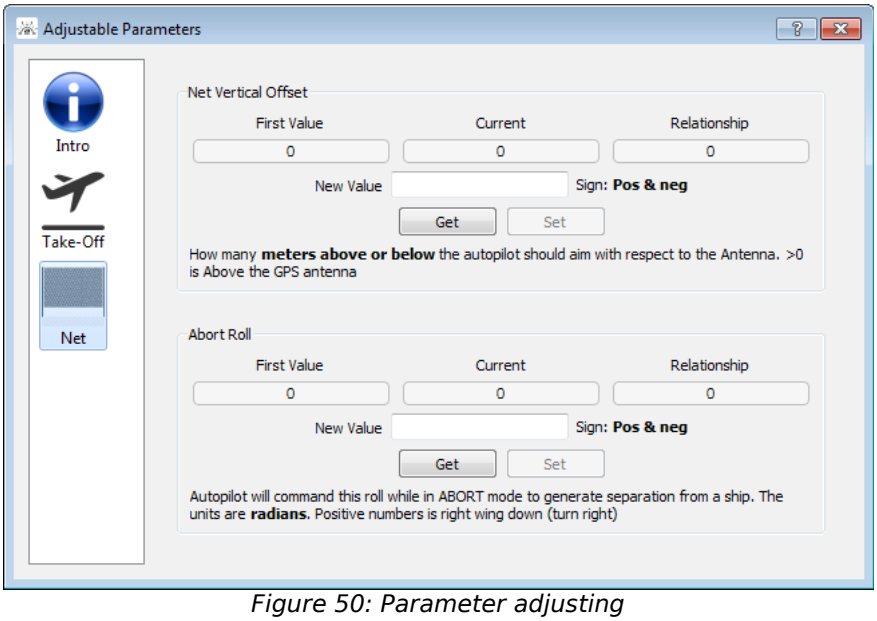


Figure 50: Parameter adjusting

The change of the parameter can be made by direct value adjustment or by relative changes.

- Absolute value: Values that can be both positive and negative will be necessary to be written directly.

- Relative: Values that do not need to change sign will be adjusted as a percentage to increase or decrease over current value.

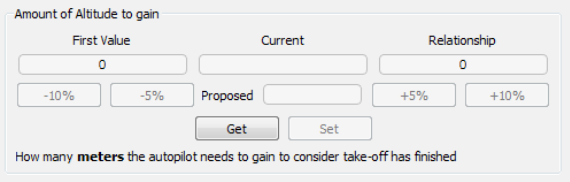


Figure 51: Relative Mode change

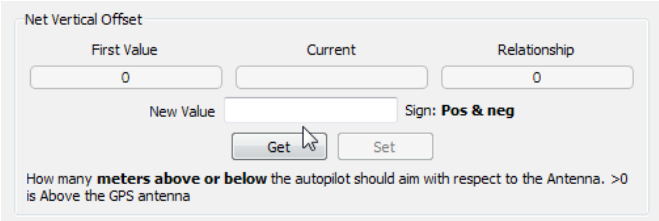


Figure 52: Absolute mode

Below every parameter a short description of the parameter effect and its unit will be shown.

To make the parameters change permanent *settings → save settings* has to be used. If a mistake is made, it is possible to power-cycle the autopilot to undo it.

Parameters accessed through this dialog can fundamentally change the behaviour of the autopilot. They may provoke a leave of controlled flight and proper training and knowledge is needed to operate this feature.

If you have any doubt, please, contact Airelectronics for support before risking your aircraft.

2.12.2 Configure GCS Hardware(Optional)

This is an optional feature, so this section may not apply to your U-See version

Tracking enabled U-Grounds can be configured through this option. Check specific U-Ground documentation for the usage of this feature.

2.12.3 Manual Trims

The manual trim dialog allows the user to change the surfaces trim of the vehicle: this allows to deflect surfaces a constant amount through all the flight envelope, thus eliminating movement tendencies acquired through change of CoG, damage to aerodynamic surfaces due to wear, etc.

For each command there are two buttons that modify the trim status and automatically upload the new values to the vehicle, meanwhile the button “Get” downloads the current values of the trims. Keeping the button pressed will continue to trim in that direction, accelerating the trim value with time.

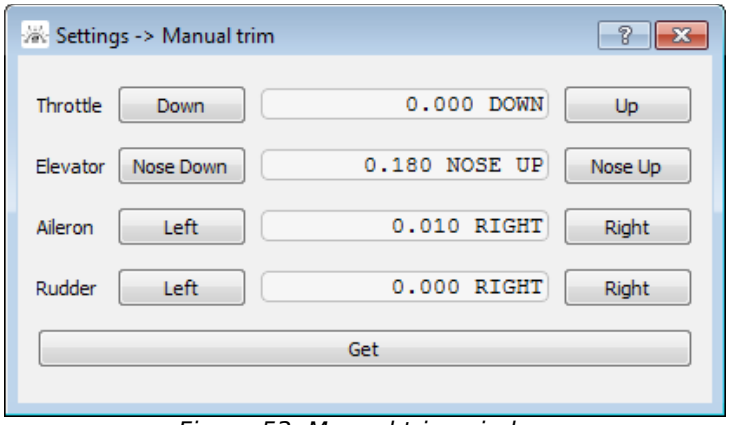


Figure 53: Manual trim window

2.12.4 Camera Joystick

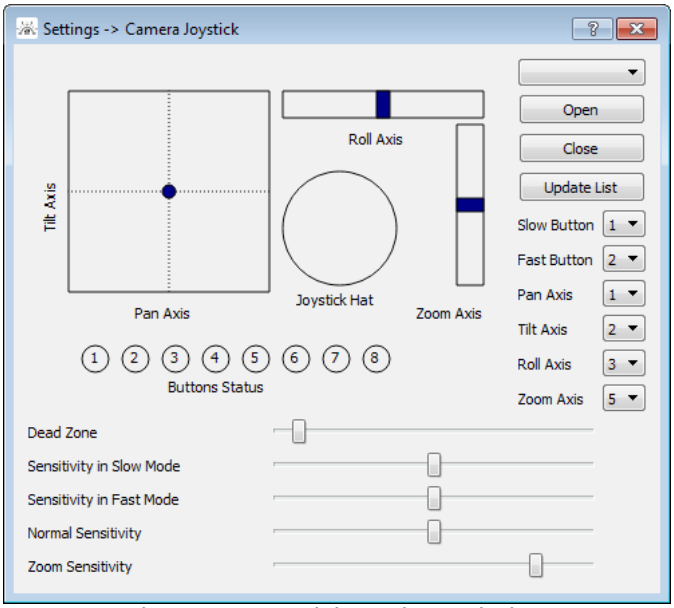


Figure 54: Joystick settings window

This dialog allows configuration and operation of a HID compatible joystick for camera control and operation.

Joystick used for control can be selected and opened[21], besides configuration of the axis and buttons used for functionality.

Current status of joystick is shown through drawn schematics. On the right, various drop downs allows selection axis or button associated to funcionality:

- Slow Button: A button that when kept pressed will reduce joystick sensitivity for fine tuning of camera pointing
- Fast Button: A button that when kept pressed will increase joystick sensitivity for fast movement of camera.
- Pan Axis: Axis in joystick that will move the camera in pan.
- Tilt Axis: Axis in joystick that will move the camera in tilt.
- Roll Axis: Axis in joystick that will move the camera in roll.

On the bottom of the dialog, dead zone in the joystick axes can be adjusted via a slider.

21 Software will open at startup last joystick used.

Also adjustable, the sensitivity of the normal, fast and slow movement.

Test should be made while on ground to assure this settings suite your application or preferences regarding camera movement.

2.12.5 Payload setting window

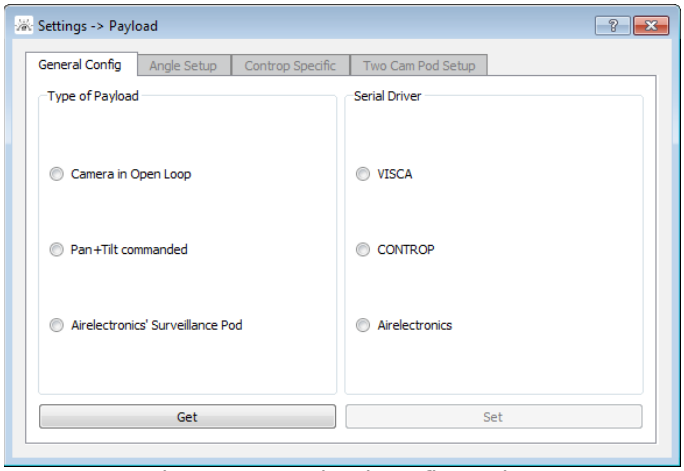


Figure 55: Payload configuration

Camera installation type can be adjusted with this dialog. Available options are:

- Pan-Tilt Servos: Two axis pan-tilt servo operated camera
- Roll-Tilt Servos: Two axis roll-tilt servo operated camera
- Open Loop Servos: No feedback modified servos.

Serial driver section allows to select what kind of RS-232 commands will be output through the payload serial port. Current supported protocols are Sony VISCA protocol and Controp protocol. Other camera interface options can be added on request.

Pan-Tilt and Roll-Tilt servo option needs extra information: Angles obtained by servo deflection has to be input for the system to know how much PWM variation needs to command for camera control. Full deflection and neutral deflection has to be given for proper operation of the camera.

Declared minimum, neutral and maximum angles for pan and tilt do affect VISCA and CONTROP protocol controlled cameras, as the autopilot will never exceed these declared limits.

2.12.6 Air Data System Settings

Adjustment to the Air Data Acquisition is made trough this window.

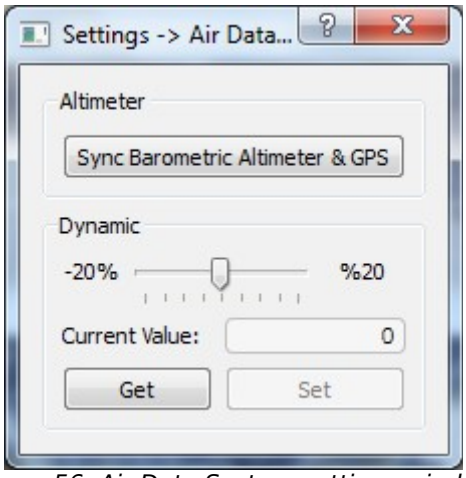


Figure 56: Air Data System settings window

With the 'Sync Barometric Altimeter & GPS' button in the 'Altimeter' section, the system altitude is adjusted to reflect precisely the instantaneous GPS altitude at that moment.

The system corrects its barometric altitude using information from the navigation fix as an input, however, if GPS initial navigation fix is of poor quality, a wrong barometric altitude correction may be introduced into the system. This button forces the recalculation of such barometric correction, thus correcting the problem.

In the Dynamic section, errors coming from pitot installation can be compensated. This dialog allows to increase and decrease pitot indication linearly from -20% to 20% compared to standard pitot sensor calibration.

To be made permanent, the changes in the section 'Dynamic' need to be saved to the non-volatile memory of the autopilot through the *Save Changes* entry in the settings menu.

The actions commanded through this settings window shall never be commanded while an aircraft is in flight. Shall any doubt about the usage of this dialog arise, please contact us before using it.

Proper operation of the Air Data System is of the utmost importance for a safe operation of the system.

2.12.7 Servos

While the Airelectronics staff will adjust the servos on your UAV for you as part of the adaptation, you may need to change a servo or move the autopilot among different units of the same model of aircraft. With the servo adjustment mode, you will be able to adjust the mechanical travels for the particular servos you use.

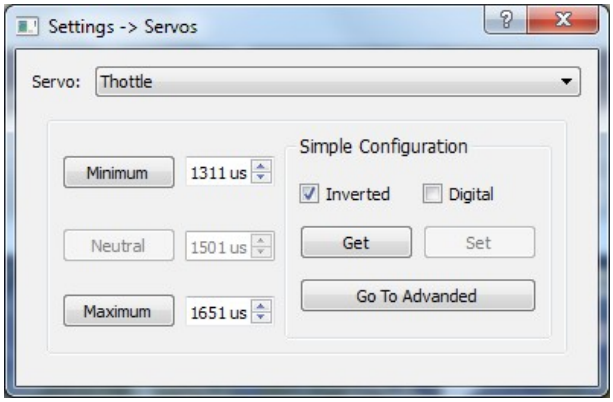


Figure 58: Servo adjusment window with simple configuration shown

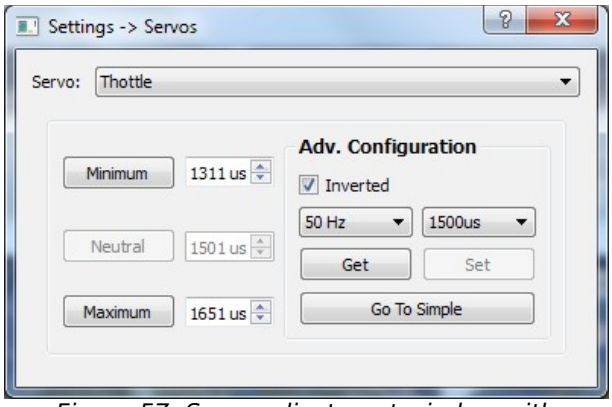


Figure 57: Servo adjustment window with advanced configuration shown

This attained through the use of the servos window, accessed by means of settings → servos menu entry.

This servo adjusmtent window has a top drop down control that selects which servo is being configured. At every moment, the proper channels for the current connected aircraft will be shown.

Below the drop-down menu to select servo, the window is divided in two zones. Left zone allows configuration of servo end-point and neutral position (if that channel has a neutral) and allows positioning the servo in that position during servo adjustment mode (through buttons “Minimum”,”Neutral” and “Maximum”). Right section allows extra options and the available settings depend on whether the channel is configured in simple or advanced mode:

- In Simple mode: Simple mode exposes a checkbox to reverse the servo movement (Inverted) and a checkbox to change the servo into “digital” mode (PWM pulse is configured to 333Hz and 1500µs neutral pulse in an easy way). Besides the checkbox, a “get” and “set button are available. When clicked, get button queries the autopilot for current in-memory values and shows them in the U-See interface. Set button, on the other hand, takes U-See values and copy them to the autopilot memory.
- In Advanced mode: Advanced mode exposes the same “inverted” checkbox to reverse servo movement direction, but also allows selection of PWM signal frequency and pulse width. Get and Set button work the same way than the simple counterpart.

The available frequencies for advanced mode are:

- 50 Hz (Safest, most usual servo frequency)
- 333 Hz (Usually, digital servos accept this frequency)
- 200 Hz
- 300 Hz
- 560 Hz (Very often, used for tail servo in helicopters).

Available pulse neutral times are:

- 1500 µs (Usual servo neutral)
- 760 µs (Used usually only with 560 Hz servos: this frequency leaves ~1786 µs available for PWM width, hence the reduced pulse width)

Advanced servo configuration mode allows any combination of frequency and pulse width,

Servos can be damaged by incorrect type of PWM signal. Before making changes servo manufacturer documentation should be checked to make sure proper settings are being applied.

(further frequencies and pulse widths are available upon request).

The procedure to adjust the mechanical travels of the system servos would be:

1. Start the servo adjustment mode on the Command Mode window.
2. Open the Servos window on *Settings → Servos.*
3. Click *Get* button to receive the servo data from the Autopilot.

4. In case of using a digital servo (300 Hz command signal frequency) tick *Digital* check box and click *Set* button.
5. *Click* '*Set min*' to move the servo to its predefined minimum position and change the value on the box to move the servo to a new position.
6. In case the servo is not moving on the desired direction tick on *Inverted check box and click Set button.*
7. Repeat the step 5, for *neutral* and *maximum* positions.
8. Press *Set* button to record the three values.
9. Open *Save Changes* on the *Settings* menu.
10. Press *Yes* to record the new values on the Autopilot.

Note: The throttle servo only accepts maximum and minimum values.

Minimum, neutral and maximum values are reported in µs. Internally, the autopilot uses a different representation of servo adjustment, so it is possible that sometimes a different number than the input may be reported. E.g. input 1500µs and 1499µs is reported. This is normal and expected behaviour.

Be aware that servo adjustment mode commands each servo independently, so, for systems that must respect some mechanical restriction between servos (e.g. a helicopter swashplate with a 4 servo configuration) it is very recommended to release the quick link to avoid damaging the servos.

Advanced servo parameter configuration has been supported in the autopilot since march 2014. Autopilots with firmware produced before this date won't answer to the “Advanced mode” Get button. When in this case, restrain usage to the simple version.

2.12.7.1 2.12.7.1 Adjusting a servo controlled Camera

If you system has a PWM servo controlled camera installed these steps should be followed to adjust it properly:

1. Configure the correspondent servos for maximum, neutral and minimum mechanical travel as indicated in section 2.12.7 “Servos”. To determine the proper setting of the “inverted” checkbox consider:
   a. Pan servo should point the camera to the right when in maximum position and to the left in minimum position
   b. Tilt servo should point the camera down when in minimum position and up in maximum position.
   c. Roll servo should rotate the camera image frame clockwise when in maximum position and counter-clockwise when in minimum position.
2. Set to neutral the pan, tilt and roll servos. (Camera should look straight ahead)
3. Command Min position in pan servo (Camera should look to the left of the vehicle)
4. Measure the angle between the line of sight of the camera and the forward orientation.

5. Command Max position in pan servo (Camera should look the right)
6. Measure the angle between the line of sight of the camera and the forward orientation.
7. Command neutral in Pan servo
8. Command minimum position in tilt servo (Camera should be looking down)
9. Measure the angle between the line of sight of the camera and the forward orientation.
10. Command maximum position in tilt servo (Camera should be looking up)
11. Command neutral in tilt servo.
12. Command minimum position in roll servo. (Camera should balance to the left, or, when looking at the image the camera produces, rotate counter-clockwise)
13. Measure the angle between the camera frame and the horizontal
14. Command Max position in roll servo (Camera should balance to the right, or, when looking at the image the camera produces, rotate clockwise)
15. Measure the angle between the camera frame and the horizontal
16. introduce the measurements information in the “Payload setting window” dialog. The pan-tilt-roll angles follow the usual body angles convention.
    a. Tilt angle is positive upwards
    b. Pan angle is positive to the right
    c. Roll angle is positive when the camera image rotates clockwise
17. Save all the changes by selecting *settings → Save Changes*

2.12.8 Pitch Throttle Curves

To set pitch and throttle curves go to *Settings → Pitch Throttle Curves.* On that window is possible to get the recorded values on the Autopilot or to set new values. It is recommended to use the values defined by the engine manufacturer.

This window is primarily intended for Rotary wing UAV and won't be available when not communicating with a rotary wing configured autopilot.

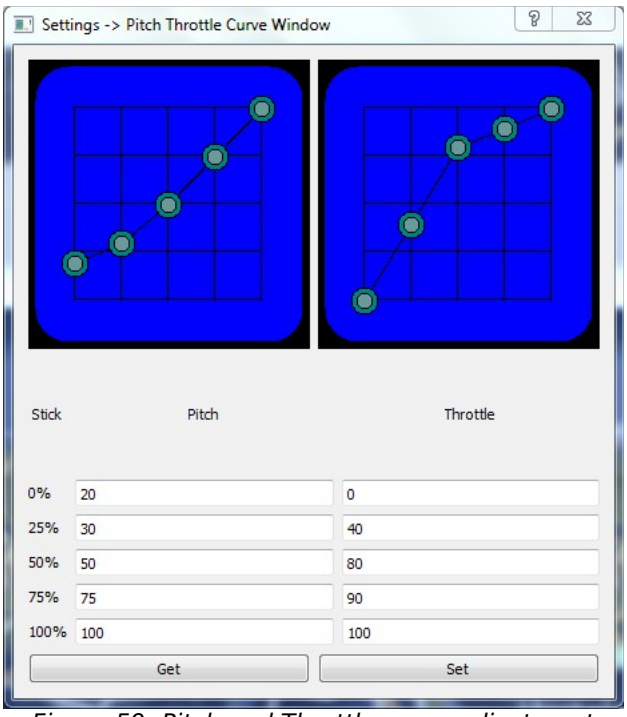


Figure 59: Pitch and Throttle curve adjustment window

2.12.9 Magnetometer Calibration

The performance of the magnetometer will greatly depend on its installation location. A magnetometer relies on the earth's magnetic field to provide heading. Any distortions of earth magnetic field by other sources such as a UAV massive iron components should be compensated for in order to determine an accurate heading. Sources of magnetic fields in any UAV include permanent magnets mostly in its motors, electric currents flowing in its wiring—either dc or ac, and Ferro-magnetic metals such as steel or iron. The influence of these sources of interference on a magnetometer accuracy can be greatly reduced by placing the compass far away from them.

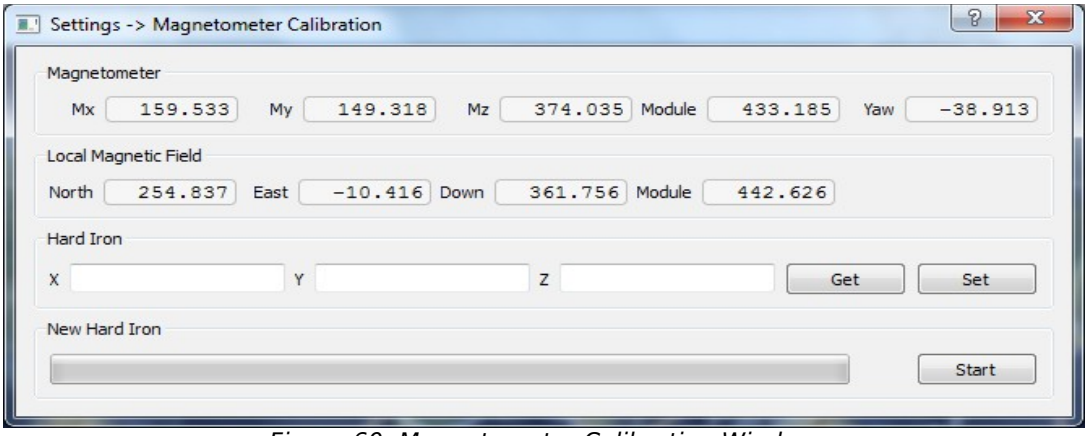

Settings -> Magnetometer Calibration
Magnetometer
Mx 159.533 My 149.318 Mz 374.035 Module 433.185 Yaw -38.913
Local Magnetic Field
North 254.837 East -10.416 Down 361.756 Module 442.626
Hard Iron
X Y Z Get Set
New Hard Iron
Start

Figure 60: Magnetometer Calibration Window

Magnetometer is very important in rotary wing UAV, do not fly a rotary wing UAV if the magnetometer alarm is triggered (red color alarm displayed).

Magnetometer is not necessary in fixed wing UAVs.

The field effects can be compensated by way of calibrating the magnetometer for a defined location in terms of magnetic interference. In order to calibrate the magnetometer the U-See operator must follow those steeps:

1.- Turn on all the electronic parts of the UAV

2.- Wait until temperature stabilizes and GPS navigation fix is valid.(GPS alarm green color)

3.- Place the UAV on a flat surface.

4.- Open the *Magnetometer Calibration* window on U-See software.

5.- Click *Start* button and manually turn the UAV more than 360 degrees. Make this turn with the UAV leveled. Do not turn too fast, finish more than one turn at the same time than the progress bar reaches 100%

6.- Click *Set* button.

7.- Check than the magnetometer alarm stays green orientating the UAV north, east, west and south. If it's not go to steep 5.

8.- Go to *Setting>Save* Changes and click *Yes* button to save the new calibration into the non volatile memory of the U-Pilot.

2.12.10 U-See settings

Under this menu entry are grouped all the options that affect the behaviour of the U-See program and are not strictly associated with an UAV.

Available settings are grouped in four main categories. One by one description will be given hereafter

2.12.10.1 Alarms & Warnings

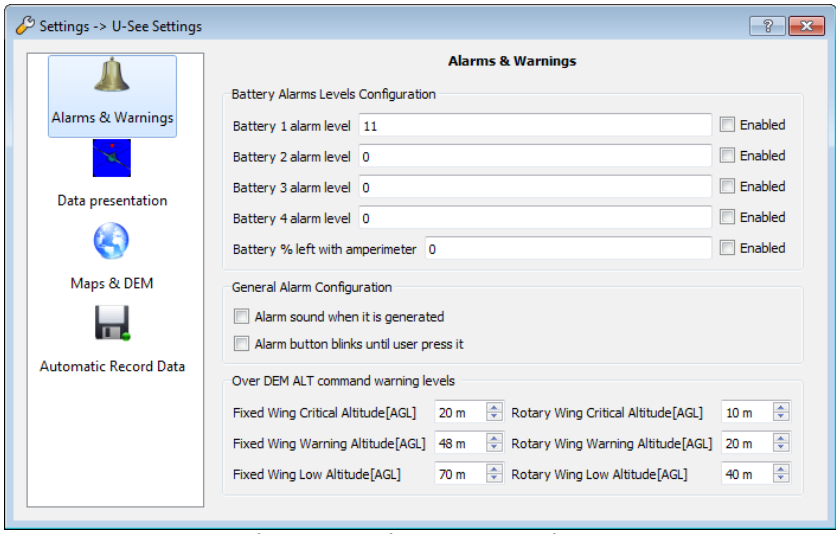

Settings -> U-See Settings
Alarms & Warnings
Data presentation
Maps & DEM
Automatic Record Data
Alarms & Warnings
Battery Alarms Levels Configuration
Battery 1 alarm level 11 Enabled
Battery 2 alarm level 0 Enabled
Battery 3 alarm level 0 Enabled
Battery 4 alarm level 0 Enabled
Battery % left with amperimeter 0 Enabled
General Alarm Configuration
Alarm sound when it is generated
Alarm button blinks until user press it
Over DEM ALT command warning levels
Fixed Wing Critical Altitude[AGL] 20 m
Rotary Wing Critical Altitude[AGL] 10 m
Fixed Wing Warning Altitude[AGL] 48 m
Rotary Wing Warning Altitude[AGL] 20 m
Fixed Wing Low Altitude[AGL] 70 m
Rotary Wing Low Altitude[AGL] 40 m

Figure 61: Alarms & Warnings

Alarms & Warning section allow to change and fine-tune the behavior of the U-See Alarm system.

This section is divided in three main sections:

- Battery related on-ground alarms: It is possible to define values at which U-See will launch an alarm, independently of autopilot on-board own alarms limits. This section allows to define a battery voltage alarm per every available channel. If at any point the voltage of the channel drops below the configured voltage, the corresponding ADC channel alarm will trigger. It is possible to define also a threshold percentage of battery below which ENG alarm will be triggered. For this alarm to work as designed, it is important to input the correct battery available capacity in Engine Data (See 2.8.7.1 Electric engine Data)
- General Alarm configuration: Through this section alarms can be configured to emit a sound whenever its status changes to an abnormal condition, and also, it is possible to make the triggered alarm blink until the user acknowledges the alarm by clicking on it. This prevents intermittent problems go unadvertised and we strongly recommend to activate both features. When configured to blink, alarms will continue to blink even if they return to nominal status.
- GPWS warning levels: The last section of the window allows configuration of the GPWS warning system levels. Rotary and fixed wing may have different warning levels. Altitudes introduced in this section are AGL (Above Ground Level) indications and the dialog will force the critical value to be lower than the warning level and those two lower than the low altitude level. For more information, see 2.5.3 GPWS Information display

2.12.10.2 Data Presentation

Customization of data presentation in State window is also allowed through this dialog, a drop-drown menu allows the selection of data presentation mode shown in the surfaces window (see Section 2.8.5 State).

Also in this section, is the selection of preferred units for every magnitude. See 2.4 Units and locale for the accurate definition of available units.

Users of the imperial measurement system should check that the definition of the units match their expected values before operating the system. Specially if you use miles for distance measurement, as there is no “standard mile” and its definition changes from country to country.

2.12.10.3 Maps & DEM configuration

This section allows to fine tune symbology presented on the map. A check is available to turn off/on:

- Calculated camera pointing target
- UAV Trail: A historic of aircraft position. Climbs at 5 m/s or higher will be painted completely red, descends of 5 m/s or more will be completely blue.
- Show Relative-GPS Info (Optional feature): This may not apply to your U-See version. This control shows/hides all Relative GPS symbology display on map. This includes moving base position as reported by relative GPS subsystem, its overlay and the base trail.
- Overlay on Map: Shows/hides on map basic information overlay.
- GPWS Overlay: Shows/hides GPWS coloured pattern on map. This doesn't affect the TERRAIN alarm or the GPWS bar diagram on the altitude sliding bar.

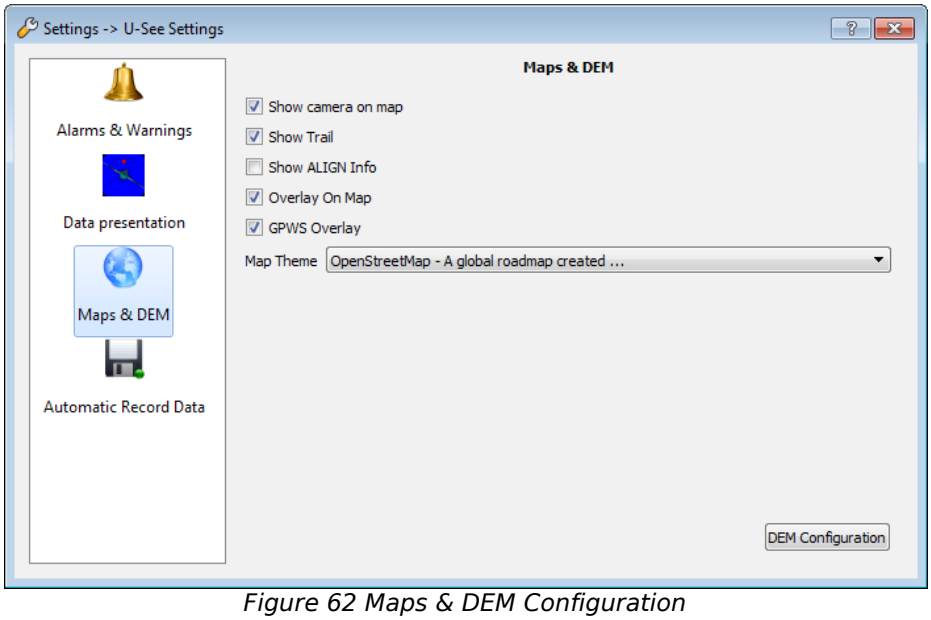


Figure 62 Maps & DEM Configuration

Map theme used for map display can be changed between the installed options in the system. Custom maps can be added using the MapManager utility distributed along U-See.

2.12.10.3.1 Dem configuration

Digital Elevation Model(DEM) Configuration is accessed through the “Dem configuration” button located on the right bottom corner of the window.

Through this dialog the source for terrain elevation in the software can be established. It will affect all software terrain related displays.

To add a source, click on the button "*New Layer*".

The valid sources for elevation data are:

- IGN-ASC files: Spanish specific version of widely availabel ASC format, as published by national geographic institute.
- GeoTiff Source: Geo-referenced Tiff files.
- DTED Source: Standard elevation format.

Besides sources of elevations, it is also important to define the priority of these sources. Each source has an attached order which is managed by moving the sources up and down in the sources stack.

When a terrain elevation is needed, software will request said elevation from the first source in the list (Query sequence can be confirmed through the ID column in the stack display). If the elevation was obtained, it will stop there; if not, it will request the next source available in the list. In case no custom source is available, the elevation will be obtained from the default DEM model.

Be advised that if a very big DEM model is loaded (> 100 Mib) there could be a delay of a pair of seconds between the loading of the file and its output is propagated to the rest of the software.

This default DEM model is a nearly global land coverage model (between 60°S and 60°N) with a grid spacing of around 1km.

Each source has to be assigned a name, a source associated filename, its type and for every source, elevation reference has to be manually established. Usually elevation data is given from the reference geoid associated with the coordinate system, however, sometimes files are encoded using elevation from the reference ellipsoid. User is required to input this information. Available Options for the "*File Altitude Data Reference*"

- Reference Geoid: File contains elevation data as measured from the reference geoid (roughly equivalent to above mean sea level)
- Reference Ellipsoid: The file contains elevation data measured from the reference ellipsoid (sometimes this is referenced as GPS altitude).

Automatic Record Data

U-See can be configured to automatically start recording data files once it is started. This eliminates the need for the operator to remember to record the telemetry before every flight as it is done automatically for him.

In this section a folder for automatic recording can be selected (Default will be C:\User\<USER>\Documents) and a basename for the recording files.

When enabled, the program will start automatically record any data that enters the telemetry system to disk. The filename generated will be:

<BaseName>_DD_MM_YYYY-HH_MM_SS

Where:

- DD is day of the month
- MM is month numbered
- YYYY is year
- HH is hour at start of recording

- MM is minute at start of recording
- SS is seconds at start of recording.

2.12.11 Auto align sensors

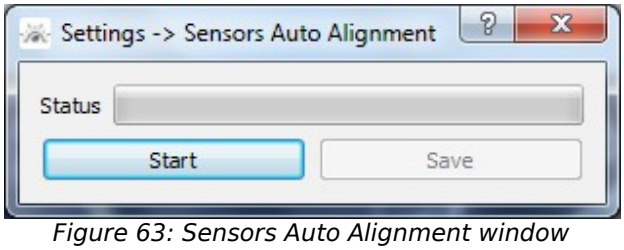


Figure 63: Sensors Auto Alignment window

It may occur, after a significant time in operation since manufacturing, that U-Pilot MEMs sensors may have experienced zero drift. This dialog accounts for such possibility and allows to reset the zero reference for your autopilot.

Sensors alignment requires the UAV to be still and with the less vibration the better. It also requires the UAV to be positioned with 0° roll and 0° pitch for proper alignment.

Before starting the alignment operation a warning dialog is presented to remind user the expected UAV state (Figure 64: Sensor Auto Alignment warning window)

Once the sensors are aligned it must be recorded to the EPCS on *Settings → Save Changes* as described on 2.12.12 Save Changes or by pressing *Save* on the dialog.

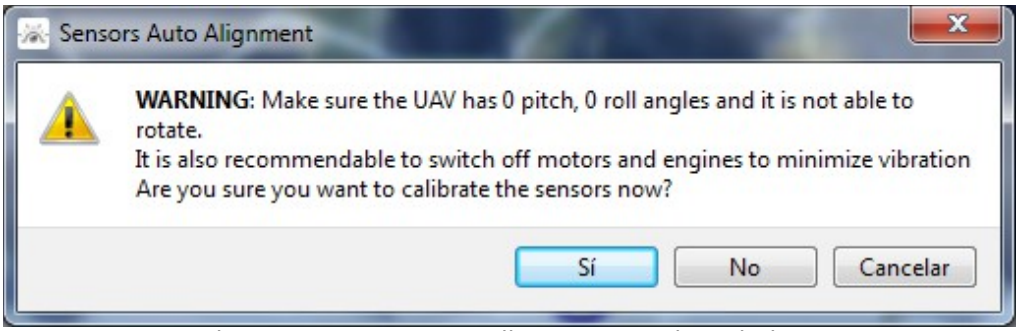

Sensors Auto Alignment
WARNING: Make sure the UAV has 0 pitch, 0 roll angles and it is not able to rotate.
It is also recommendable to switch off motors and engines to minimize vibration
Are you sure you want to calibrate the sensors now?
Sí
No
Cancelar

Figure 64: Sensor Auto Alignment warning window

2.12.12 Save Changes

All settings changed are not saved to the Autopilot until “Save Changes” is used. Once the operator accepts the warning message, all settings are recorded to the Autopilot and the old settings are lost.

IMPORTANT: THE SETTINGS NOT RECORDED TO THE AUTOPILOT WILL BE LOST WHEN THE AUTOPILOT IS SWITCHED OFF.

The recorded information is:

- The current Flight Plan
- The current Servo Configuration, maximum, minimum and neutral positions
- The current Landing Site definition
- The current Pitch and Throttle curves
- Magnetometer calibration

Appendix A Matlab script for data analysis

This script will load data file and present some interesting figures.

```
%% -------------- Start of file ------------
clear all
data=load('Y:\Path_to_Data\datafile.txt');

Pitch = data (:,1);
Roll  = data (:,2);
Yaw   = data (:,3);

CommandedPitch = data(:,4) ;
CommandedRoll = data (:,5);
CommandedYaw = data (:,6);

Battery1 = data (:,7);
Battery2 = data (:,8);
Battery3 = data (:,9);
Battery4 = data (:,10);

Altitude = data (:,11);
Latitude = data (:,12);
Longitude = data (:,13);

IAS = data (:,14);
GroundSpeed = data (:,15);

CommandedIAS = data (:,16);
CommandedAltitude = data (:,17);

VNorth = data (:,18);
VEast = data (:, 19);
VDown = data (:,20);

close all

figure
hold on;
grid on;
plot (Pitch,'r');
plot (Roll,'g');
title ('Pitch & Roll');
legend ('Pitch [degrees]','Roll [degrees]');

figure
hold on;
grid on;
plot (Pitch,'r');
plot (CommandedPitch,'b');
title ('Pitch command loop');
legend ('Pitch','Commanded Pitch');

figure
hold on;
grid on;
plot (Roll,'r');
plot (CommandedRoll,'b');
title ('Roll command loop');
legend ('Roll','Commanded Roll');

figure
```

```
hold on;
grid on;
axis equal;
plot (Longitude,Latitude);
title ('Position 2D');


figure
hold on;
grid on;
title ('Speed');
plot (IAS);
plot (GroundSpeed,'r');
legend ('IAS [km/h]','GroundSpeed [km/h]');

figure
hold on;
grid on;
title ('Speed in Horizontal axis');
plot (VNorth,'r');
plot (VEast,'g');

legend ('Speed North [km/h]','Speed East [km/h]');

figure
hold on
title ('Vertical speed');
grid on;
plot (VDown./3.6);
legend('Speed Down [m/s]');

figure
hold on;
grid on;
title ('Altitude');
plot (Altitude,'r');
plot (CommandedAltitude,'b');
legend ('altitude [m]','Commanded Altitude [m]');

figure
hold on;
grid on;
title ('Speed Control Loop');
plot (IAS,'r');
plot (CommandedIAS,'b');
legend ('IAS[km/h]','Commanded IAS[km/h]');

figure
hold on;
grid on;
title ('ADC readings');
plot (Battery1,'r');
plot (Battery2,'g');
plot (Battery3,'b');
plot (Battery4,'k');
legend ('ADC in 1','ADC in 2','ADC in 3','Main system voltage');
%% -------------- End of file ------------
```

Appendix B Matlab script for pointing camera coordinates

This script will load data file and present some interesting figures.

```
%% -------------- Start of file ------------
clear all
data=load('Y:\Path_to_Data\datafile.txt');

airplane_pitch = data(:,1);
airplane_roll = data(:,2);
airplane_yaw = data(:,3);
airplane_latitude = data(:,4);
airplane_longitude = data(:,5);
airplane_altitude = data(:,6);
camera_pan = data(:,7);
camera_tilt = data(:,8);
camera_horizontal_North = data(:,9);
camera_horizontal_East = data(:,10);
camera_horizontal_Down = data(:,11);
pointed_latitude = data(:,12);
pointed_longitude = data(:,13);
pointed_altitude = data(:,14);
UTC_hour = data(:,15);
UTC_minute = data(:,16);
UTC_second = data(:,17);


figure
plot(airplane_latitude,airplane_longitude)
hold on
plot(pointed_latitude,pointed_longitude,'r')
plot(airplane_latitude,airplane_longitude,'o')
plot(pointed_latitude,pointed_longitude,'ro')
axis equal; grid on; legend('Airplane','Camera');

figure
plot(airplane_pitch)
hold on
plot(airplane_roll,'g')
plot(airplane_pitch,'o')
plot(airplane_roll,'go')
grid on;legend('Pitch','Roll')

figure
plot(airplane_yaw,'r')
hold on
plot(airplane_yaw,'ro')
grid on;legend('Yaw')

figure
plot(camera_horizontal_North)
hold on
plot(camera_horizontal_East,'g')
plot(camera_horizontal_Down,'r')
plot(camera_horizontal_North,'o')
```

```
plot(camera_horizontal_East,'go')
plot(camera_horizontal_Down,'ro')
grid on;legend('Camera North','Camera East','Camera Down')

figure
plot(pointed_altitude)
hold on
plot(pointed_altitude,'o')
grid on;legend('Pointed Altitude')
%% -------------- End of file ------------
```

Appendix C Change log

This annex describes changes introduced to this document.

Date	Changes
2015/02/20	• Document version 1.25 • New cover graphics • Added indications in the document that MacOS X is now considered a second-tier OS • Updated information related maximum number of flightplan points to reflect the current autopilot limit: 200 points • Added description of multiple map theme support. • Software has switched from hard-coded units to user-configurable. This has been reflected all through the document • Incorporated some optional task-specific dialogs and options into the main documentation. These feature have been marked as “optional” • Left and right mouse click has been reversed by overwhelming request by customers. Document updated. • Updated serial communications dialog description. Export data in real-time description added. • Added internal temperatures in sensors view. • Added extra possible states of barometric correction state in sensors view • Updated state display dialog to reflect current software release. Prominent changes to the alarms: they gain a possible warning state (orange). • Extra and special flight modes added to the documentation marked as optional features for completeness. • Updated engine data description and added documentation for ME03 ECU page. • Added time log dialog description • Added relative GPS dialog description (optional feature) • Added video capture support description (optional feature) • Added user-adjustable gains adjustment dialog (optional feature) • Configure GCS Hardware dialog (optional feature) • Removed appendix C: Fully configurable joystick support has made its existence not necessary • Documented optionally available video capture feature • Documented time log dialog under *view menu*. • Documented optional advanced runway dialog under *pre-flight menu* • Documented Landing control dialog • Updated main command window description to include optionally available options. • Updated post-flight expansion tool: only one central facility for file expansion and added mention of NMEA support • Renamed Ground Settings to U-See settings to reflect current software state. Updated Options description in this module. • Added description of optionally available “Gains adjustment” for completeness • Improved surfaces section text and added a figure with all symbology active. • Added a warning about change in behaviour in the way we interact with the map.
2014/07/21	• Version of document up to 1.24 • Added Engine management window documentation.
2014/07/01	• Version of document up to 1.23 • Updated pictures to match the window titles in the software. • Added Sensors summary window documentation. • Removed GPS and GPS Signal windows documentation. • Removed sensor selection option from auto alignment window. • Changed Flaps window name to Aux surfaces window. • Documented information label option next to the vehicle over the map.

Date	Changes
2014/05/19	• Version of document up to 1.22 • Introduced a change log table • Updated fixed wing command mode window snapshot • Added a description of CATARM mode. • Updated the servo adjustment window documentation to describe new appearance and functionality in latest version. • Updated payload settings window to reflect inclusion of CONTROP protocol support

If you need a previous version of documentation, please, contact us at info@airelectronics.es